REINFORCING SCIENCE-POLICY INTERFACES FOR INTEGRATED BIODIVERSITY AND CLIMATE KNOWLEDGE AND POLICIES

Mapping and Analysing Potentials and Barriers of National Knowledge Uptake:

Social Network Analysis across cases of Armenia, Colombia, Democratic Republic of Congo, Finland, Germany, Hungary and Spain

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Summary

The urgency and complexity of biodiversity and climate issues have led international bodies such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to produce comprehensive global assessments, and in the case of IPBES also regional assessments which for some applications may be more relevant at national levels. However, the impact of this knowledge ultimately hinges upon who accesses it, how it is interpreted, and through what channels it is disseminated nationally. Little comparative analysis has previously explored these dynamics in a structured manner, a gap that this report aims to fill. This report analyses how biodiversity and climate-related scientific knowledge flows within the national policy systems of seven countries: Armenia, Colombia, Democratic Republic of Congo, Finland, Germany, Hungary, and Spain. By combining Social Network Analysis (SNA) with structured stakeholder surveys, the study provides a detailed mapping of information flows, identifies preferred communication formats, and highlights the factors enabling or impeding the effective integration of scientific findings into policy decisions at the national level. Drawing upon survey responses from 225 national stakeholders across government ministries, research institutes, NGOs, businesses, and media organizations, the analysis employed a suite of quantitative and qualitative methods. These included network visualizations, detailed Sankey and chord diagrams illustrating information pathways, and qualitative thematic coding of stakeholder views regarding preferred channels and key enablers of effective knowledge transfer.

We conceptualise the science–policy interface as a bidirectional system: policy priorities and constraints inform scientific questions, while scientific synthesis informs policy design and implementation. In this report we identify who provides and who receives climate–biodiversity knowledge across actor groups and countries, and we highlight where feedback channels appear thin or absent

Findings reveal three dominant configurations of national knowledge systems. In Germany and the Democratic Republic of Congo, a highly centralised *hub-and-spoke* structure allows rapid and authoritative dissemination of official information, but simultaneously marginalises local authorities, businesses, and civil society actors. Colombia and Hungary represent a more balanced approach, a *hybrid core*, where ministries share central positions with major NGOs or research institutes, facilitating greater dialogue, although links with the private sector remain underdeveloped. Finland, Spain, and Armenia exhibit a *polycentric commons* structure, characterized by multiple influential actors and extensive knowledge sharing. While robust, these systems risk forming exclusive expert circles, limiting the participation of new or peripheral actors. The report identifies critical issues arising from the communication formats through which knowledge is disseminated. Countries relying predominantly on lengthy policy documents inadvertently exclude resource-constrained actors, such as local municipalities and SMEs, who often lack the capacity to process extensive texts. Digital-first platforms, prevalent in Finland and Colombia, extend geographical reach but require substantial digital literacy, potentially side lining less technically equipped users. Direct and relational methods (workshops, training, and informal dialogues), heavily employed in Hungary and Armenia, build trust but limit participation to established networks. Spain uniquely adopts a mixed-format strategy, utilizing multiple communication channels concurrently; however, even in this balanced approach, actors lacking formal institutional ties may still struggle to participate meaningfully. Across all cases, stakeholders emphasized consistent priorities for improving national science-policy interactions. Respondents call for scientific outputs that are clear, tailored to specific audiences, and accessible without sacrificing complexity. There is strong demand for interoperable, standardized data platforms that integrate diverse sources of information. Furthermore, participants underline the importance of aligning scientific recommendations with local feasibility, advocating for the co-production of tools and approaches with on-the-ground practitioners. Enhanced political capacity, ensuring that decision-makers can interpret and utilize complex global assessments (e.g., IPCC, IPBES), is considered essential. Stakeholders suggest structured training programmes and clear institutional responsibilities ("gatekeepers") to facilitate rapid policy uptake. They also highlight the importance of breaking down sectoral silos, recommending more systematic integration of biodiversity and climate objectives into broader policy areas such as finance, land-use, and health. Finally, long-term investment in effective science communication, environmental education, and peer-to-peer learning is consistently recognized as foundational for sustained societal engagement and transformative policy action.

These insights suggest concrete strategic avenues to strengthen science-policy interfaces nationally. Key recommendations include targeted investment in dedicated brokerage capacities (e.g., NGOs, think-tanks, regional agencies), mandating multi-format dissemination of scientific findings (combining succinct policy briefs, openly accessible data sets, and interactive engagement events), providing dedicated resources and training for policymakers to navigate global assessment reports, explicitly facilitating vertical knowledge flows between national and local governance layers, and establishing regular, transparent monitoring of inclusion and knowledge uptake over time. Building on the empirical findings and stakeholder priorities identified across the seven case countries, this section outlines a practical roadmap of actionable steps. These are designed to assist national policymakers, intermediaries, and supporting institutions in overcoming current barriers to knowledge uptake and enabling more effective integration of biodiversity and climate science into policy processes. We aim to translate these findings into a practical roadmap that specifies who should act on each recommendation and how to monitor progress.

List of abbreviations

SNA: Social Network Analysis

IPCC: Intergovernmental Panel on Climate Change

IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IUCN: International Union for Conservation of Nature

UNEP: United Nations Environment Programme

CBD: Convention on Biological Diversity

ARM: Armenia

COL: Colombia

DRC: Democratic Republic of Congo

FIN: Finland

GER: Germany

HUN: Hungary

ESP: Spain

1 Introduction

The triple crises around biodiversity loss, climate change and pollution need an integrated knowledge base to take decisions and manage trade-offs (Shrivastava et al. 2024). Addressing the root causes of these crises demands coordinated action across government levels and sectors and the engagement of other stakeholders including businesses and civil society. However, decision making across sectors remains fragmented and incoherent (Runhaar et al. 2024; Perrson et al. 2018), resulting in parallel institutional structures, conflicting regulations and narratives, and ultimately undermining both policy effectiveness and the efficient use of public resources.

This fragmentation extends to the domain of knowledge provision and science–policy interactions, not only between climate and biodiversity regimes, but also within them (Pascual et al. 2022; Medvedieva et al. 2018). Scientific evidence is often interpreted selectively by different interest groups (Jokinen et al., 2018), fails to capture the full complexity of policy trade-offs (Perino et al., 2022), or is partially disregarded altogether (Carroll et al., 2017; Lemly & Skorupa, 2012; Rose et al., 2020; Spierenburg, 2012; Wallington et al., 2005).

The global assessments of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) represent key efforts to harmonize and consolidate knowledge for decision-making. These global assessments are designed not only to synthesize the best available science but to support evidence-informed decision-making across governance levels (Beck et al., 2014; Turnhout et al., 2016). Yet, the availability of scientific knowledge does not ensure its uptake or use in policy processes. As highlighted in the science–policy literature, the translation of complex, uncertain, or contested knowledge into political action remains a persistent challenge (Haas, 1992; Jasanoff, 2004).

National-level uptake depends on how knowledge circulates, in particular who accesses it, who reframes it, and through what institutional and relational structures (Sarkki et al., 2015; Cvitanovic et al., 2017; Turnhout, 2018). Sectoral and organizational silos contribute to this fragmentation, as actors rely on selective information networks that shape what knowledge is prioritized and what is excluded. In addition, uncoordinated knowledge and innovation systems certain disciplines and knowledge systems are stronger consulted while others remain ignored, specifically Indigenous and Local Knowledge (Franzeskaki et al. 2022). While platforms like IPBES and IPCC generate credible knowledge, the national-level dynamics of how this knowledge is interpreted and exchanged among state, civil society, and private actors remain comparatively understudied (Sarkki et al., 2015; Gustafsson & Lidskog, 2018; Rose et al., 2020).

To address this gap, Social Network Analysis (SNA) offers a valuable methodological approach by mapping and analyzing the relationships and information flows among actors within a network. By examining the structure of these networks, SNA can identify key actors, such as knowledge brokers and gatekeepers, and reveal patterns that influence the dissemination and uptake of information. Conceptually, we treat the interface as bidirectional. Empirically, this study reports directional patterns of provision and receipt among actor groups, and discusses feedback using complementary "links between organisations" figures and respondents' reflections.

Function 2 of RESPIN focuses on empowering knowledge users at national and subnational levels by identifying gaps, needs, and barriers to the uptake of biodiversity- and climate-related knowledge, particularly beyond the environmental sector. It aims to support coherent policymaking and build synergies across IPBES, IPCC and national institutions. As part of Function 2, we apply the SNA to study the flow of biodiversity and climate-related knowledge between key national actors in seven country cases: Germany, Spain, Armenia, Hungary, Colombia, DR Congo and Finland. Analysis builds on previous research in environmental science-policy interfaces, which highlights the importance of network structures in shaping knowledge exchange, trust, and decision-making processes (Hegger et al., 2012).

The objectives of this task are as follows:

- Map the key actors involved in biodiversity and climate-related decision-making processes.

- Analyze the structure of knowledge exchange networks across government institutions, research organizations, private sector entities, and civil society.
- Assess the role of different information formats (digital, official documents, direct communication) in shaping knowledge uptake.
- Compare patterns of knowledge exchange across country cases to identify enabling conditions and barriers for science-policy integration.

By employing SNA methods, this deliverable contributes to ongoing discussions on how scientific knowledge is accessed, shared, and internalized within policy structures. The findings help identify key knowledge brokers, gaps in information exchange, and best practices for improving science-policy uptake at the national level.

2 Methods

2.1 Study Design

The SNA survey is being conducted in seven country cases**:** Germany, Spain, Finland, Hungary, Colombia, Finland and the Democratic Republic of the Congo. These countries were selected to capture variation in science-policy interactions**,** considering factors such as the strength of institutional development, government funding, geographical variation and representation in IPBES-IPCC processes. A structured questionnaire was developed to capture key knowledge-exchange relationships among national-level actors involved in biodiversity and climate change policymaking. The survey instrument was designed in alignment with insights from other partners while ensuring comparability across country cases.

2.1.1 Actor Groups

To analyze how information circulates between organizations within national biodiversity–climate systems, we organized actors into six functional categories. These actor groups were standardized across all country cases and used in the SNA survey to ensure conceptual consistency and cross-national comparability. Each organization mentioned by respondents was coded into one of the following categories:

Government and Policy-Making: This group includes ministries, national and subnational government agencies, and policy authorities responsible for environment, economy, energy, agriculture, or cross-sectoral coordination. These actors are central to agenda-setting, regulatory development, and formal decision-making processes.

Private Interest Groups: This group encompasses industry actors, business alliances, banks, corporate innovation hubs, and professional associations. These actors often bring sectoral expertise and economic influence, and may engage in sustainability strategy, lobbying, or implementation of private standards.

Public Interest Groups: This group includes NGOs, grassroots movements, citizen alliances, advocacy groups, and civil society organizations advancing biodiversity and climate justice goals. These actors typically engage through campaigning, participatory governance, and watchdog roles.

Scientific Institutions: This group comprises universities, public and private research institutes, science-policy advisory platforms, and research funding agencies. Scientific institutions are primary producers of knowledge and evidence, and play a critical role in translating research for policy relevance.

Think Tanks and Capacity-Building Organizations: This group includes policy think tanks, consulting firms focused on sustainability, and organizations involved in training, technical assistance, or organizational learning. These intermediaries often broker knowledge between science, policy, and practice.

Media: This group includes traditional outlets (e.g., newspapers, radio, television), digital platforms, and independent science communicators. Media actors influence public discourse and help translate complex knowledge into accessible narratives.

These actor groups were selected to reflect structurally distinct roles within national knowledge systems: from formal decision-making (e.g. ministries), to knowledge production (e.g. universities), public influence (e.g. media), and interest-based advocacy or lobbying (e.g. private and public groups). Grouping institutions this way allows us to investigate not only individual ties, but also broader structural dynamics, including which types of actors dominate, bridge, or are peripheral in information ecosystems. This categorization also aligns with prevailing literature on environmental governance, policy networks, and science–policy interfaces, enhancing the theoretical robustness of our analysis.

2.1.2 Information Formats: Modes of Receiving Biodiversity–Climate Information

In addition to identifying information providers, the RESPIN SNA survey asked respondents to indicate the format in which they most frequently receive biodiversity–climate-related information from each organization. This distinction is critical for understanding how different communication modes structure access, influence, and engagement across the national science–policy interface. Respondents selected from the following four options:

Digital and Online Media: This includes websites, social media platforms, and digital newsletters. These channels enable broad dissemination and rapid access to information, often designed for visibility and reach rather than targeted influence.

Official and Formal Documents: This refers to policy reports, formal summaries for decision-makers, technical publications such as IPCC and IPBES reports, and institutional information sheets. These materials are typically authoritative and institutionally endorsed, playing a formal role in policy deliberation and documentation.

Direct and Indirect Communication: Includes emails, phone calls, informal exchanges, expert consultations, workshops, and conferences. These formats are typically dialogic or relational, often grounded in trust, and are critical for policy negotiation and co-production.

No Information Received in any format: Respondents could indicate if they did not receive information from a listed organization in any of the above formats, allowing us to capture gaps in the information landscape.

Why analyse formats? Understanding formats helps reveal not only what information is shared and by whom, but how communication strategies may affect visibility, uptake, and legitimacy. Different formats imply different levels of institutional formality, accessibility, and engagement. For instance, official documents carry institutional authority but may be less timely or responsive, whereas direct exchanges foster trust and influence but are limited in scale. Digital media increases reach but may lack context or depth. By capturing these distinctions, we are able to interrogate how communication strategies differ across actor types, and how these strategies shape power dynamics in the science–policy interface. The inclusion of a "no information received" category is especially valuable for identifying information blind spots, actors that are structurally disconnected from national biodiversity–climate conversations, whether by choice or exclusion.

2.2 Sampling Strategy

We aimed to gather insights into national-level biodiversity and climate information exchange across seven country cases. Our initial sampling strategy sought to include between 40 and 60 respondents per country, based on the assumption that this range would be sufficient to capture the diversity of relevant organizational perspectives and provide a robust basis for network analysis, especially in countries with complex governance systems and dense policy networks.

However, during survey deployment, it became evident that reaching this target was not feasible in all contexts. Country teams faced practical constraints, including limited availability of stakeholders, institutional turnover, and challenges in securing responses from private sector and civil society actors. In response, the sampling strategy was adaptively refined to aim for up to 40 respondents per country, with the priority of maintaining diversity across key actor groups rather than strict numerical equivalence.

The final number of responses per country was as follows, with a total of 225 surveys being analysed: Germany: 48; Hungary: 41; Finland: 38; Democratic Republic of Congo (DRC): 38; Colombia: 23; Spain: 19 and Armenia: 18.

While the number of respondents varied, all country teams ensured the inclusion of actors from at least the following three core groups: Government ministries and public agencies involved in climate and biodiversity policy; Civil society organizations, including NGOs, platforms, and advocacy groups engaged in knowledge mobilization; and Private sector stakeholders, including businesses and industry representatives relevant to climate and biodiversity governance. This purposive, actor-stratified sampling strategy was designed to capture the structure and diversity of national knowledge systems, rather than achieve statistical representativeness. The aim was to enable a comparative, qualitative analysis of how different actor types exchange information, engage with knowledge platforms, and contribute to biodiversity–climate integration at the national level.

2.3 Data Collection

The survey was administered online using LimeSurvey, with targeted email invitations sent to selected stakeholders in each country. Country teams were responsible for curating and refining respondent lists to reflect national institutional landscapes and ensure contextual relevance. The survey was offered in six languages: English, German, Spanish, Finnish, Hungarian, and French, to accommodate linguistic diversity and maximize participation. In some cases, additional follow-up by phone or direct email was used to encourage responses from underrepresented sectors.

2.4 Data Analysis

2.4.1 Quantitative Analysis

All quantitative analyses were conducted using R (version 4.x), drawing on a suite of packages including tidyverse, igraph, ggraph, ggalluvial, patchwork, and RColorBrewer. The data workflow was organized into a structured pipeline, encompassing initial cleaning, network construction, and visual representation.

Data Preparation and Cleaning

Raw survey exports were collected separately for each country in Excel format. Using the readxl package, we imported the datasets and retained only the relevant columns: respondent identifiers, actor categories of information receipt, and binary fields indicating information receipt across provider-format combinations. Column names were cleaned and standardized for clarity and consistency. Where needed, organization and actor-category names were translated into a uniform English key, for instance, “Ympäristöministeriö” was recorded as “MinistryBiodiversityClimate” in case of the Finnish survey, to ensure comparability across countries.

Edge List Construction and Normalization

To analyze the flows of information between actor types, the data were reshaped from wide to long format using pivot_longer(), with each record capturing a single response regarding receipt of information from a specific provider in a specific format. Combined strings were separated into two distinct variables: ActorCatProviding and Format. Entries labelled "no information received" were excluded from the analysis. Edges (information flows) were aggregated at the respondent-provider level, and duplicates were collapsed to produce a raw count (Weight) for each unique edge. To account for differences in response volume across receiving actor types, we normalized each edge relative to the total number of respondents

from that actor group: Normalized Flow = Weight/ (Total Responses for that Receiver Group). This produced a standardized weight (0–1) for each edge, allowing for cross-case comparison of flow intensity.

Network Construction and Visualization

Network graphs were constructed from the normalized edge lists using the igraph package. For each provider node, we computed the total outgoing flow to determine node size, and pre-assigned colour codes to distinguish between different actor categories (e.g., ministries, civil society, scientific institutions). Visualizations were generated with ggraph, using a force-directed layout (layout = "fr"). Edges were drawn with width proportional to normalized flow; nodes were scaled by their total outgoing flow; and labels were repelled to avoid overlap. Legends for edge width, node size, and color were arranged consistently, and final figures were exported as high-resolution PNG files using ggsave().

Sankey Diagrams

To represent the structure of information flows across communication formats, we generated Sankey diagrams using the ggalluvial package. Three-axis diagrams illustrated flows from provider → format → receiver, with ribbons colored by format type (ONLINE, OFFICIAL, DIRECT). Labels on the middle (format) axis were rotated for readability, and overflow clipping was disabled to allow full display of category names. Two-axis diagrams (provider → receiver) were also produced, emphasizing direct interactions between actor categories. In both cases, axes were labeled to enhance interpretability, and color coding was applied either by provider type or format.

Descriptive Analyses

To analyse patterns of respondent contributions and perceptions, we produced a set of descriptive charts: For Question 4 (roles and contributions), we generated bar charts showing the total number of "yes" responses for each contribution type (e.g., decision-making, technical expertise, internal communication), both in aggregate and disaggregated by actor category. The latter was displayed as a stacked bar chart with in-bar percentage labels. For Question 10 (agreement with statements on enabling conditions), we plotted the distribution of responses on a 1–5 scale using faceted bar charts. A dashed red line indicated the mean response level. We also visualized actor-specific response distributions with horizontal stacked bars (coord_flip()), applying a color palette for visual distinction and placing the legend below the chart. All figures were exported in PNG format for consistency and quality assurance across outputs.

Demographic Summaries: Basic demographic and organizational summaries were compiled using dplyr::count(), including respondent distribution by country, actor category, and self-identified role. Where relevant, these were visualized using standard bar plots to provide contextual overview of the sample.

Organizational Level Information Flows

In addition to the format-based Sankey diagrams and actor-group-level SNA maps, we constructed an organization-level social network to visualize the directional flow of information between specific organizations named by survey respondents. This visualization was built using data from open-ended survey questions, specifically the following: "From which three organizations do you most frequently receive information on biodiversity and climate issues?" (Q5); and "To which three organizations do you most frequently forward or communicate such information?" (Q8). The network enables a granular, relational view of how knowledge circulates within the national context, distinguishing between incoming flows (receiving information) and outgoing flows (forwarding information) for each organization.

Data Cleaning and Processing: Open-text responses from Questions 5 and 8 were cleaned and coded manually using Excel. To ensure consistency across countries and reduce ambiguity, organization names were standardized. To address inconsistencies (e.g., spelling variants or abbreviations such as "UNFCCC" vs. "UN"), a translation sheet was developed and applied post-hoc. For each country, we reshaped the data to build two edge lists: one for receiving relationships (actor group X receives information from

organization Y), and one for forwarding relationships. These were combined into a single edge list with a direction and a "relation" attribute. To visualize the network we used the program Gephi. The combined edge list produced in R was uploaded in Gephi to produce the network. Gephi automatically aggregates duplicates. The color and the thickness of the arrows represents the directionality of flow and how often this specific flow has been mentioned (Pink = receiving information; Green = forwarding information). Diagrams were rendered as high-resolution PNG images for integration into the results.

Unlike the general SNA and Sankey visualizations, where actor categories or pre-listed organizations were used, this detailed network visualization diagram relies entirely on free-text inputs from respondents. As such, it reflects only the subset of organizations voluntarily named and does not include all surveyed entities. Some named organizations were not among the respondents and thus appear as external nodes, while others reflect reciprocal flows among participants. This method provides valuable insight into perceived information networks, including prominent brokers and bilateral relationships, but should not be interpreted as a complete institutional map. The diagrams complement, and do not replace, the more structured network analyses elsewhere in the report.

2.4.2 Qualitative Data Analysis: Perception on Cooperation and Conditions for Knowledge Exchange

In addition to the quantitative analysis of structured survey responses, we conducted a qualitative content analysis of open-text responses to two key survey items. The questions were the following: "Which organizations would you like to cooperate more with on biodiversity and climate issues, and in what formats?" (Q9) and "What would help improve the dissemination and use of biodiversity and climate-related information in your national context?" (Q11) (for the detailed survey structure please refer to Appendix A). These questions were included to capture respondents' preferences, experiences, and suggestions in their own words, allowing for a more nuanced understanding of how knowledge flows might be improved or constrained beyond what closed-format questions can reveal.

Given the exploratory nature of the data and the limited volume of responses per country, we used a qualitative content analysis approach focused on thematic coding. Responses were reviewed manually and coded using Excel spreadsheets, following an inductive–deductive hybrid approach: First, a small set of responses were reviewed to inductively develop an initial list of recurring themes and concepts. Then, this initial short list of codes was refined iteratively and applied deductively across all responses in each country dataset, allowing for both consistency and sensitivity to emergent, context-specific ideas. Codes were applied at the segment level (phrases or short statements).

For Q9, coding focused on identifying the types of organizations with which respondents expressed a desire to strengthen collaboration (e.g., ministries, NGOs, research institutions, media) and the preferred formats of cooperation (e.g., joint workshops, informal networks, formal agreements). For Q11, codes reflected respondents' proposed solutions to enhance information dissemination and use. Recurring themes included, for example: Strengthening the input of scientific knowledge; Enhancing cooperation at the local and regional level; Providing actionable policy options; Increasing political prioritization and public awareness; Improving access to comprehensible and standardized information; Strengthening intersectoral coordination and media strategies; Supporting education and youth engagement and Integrating biodiversity and climate into economic decision-making

2.5 Limitations

A few limitations emerged during the analysis process. First, we faced some visualization constraints. Initial attempts to overlay all formats in a single multi-relational network led to dense and uninterpretable visuals due to the volume of responses and multiple format attributes per respondent. While the original intention was to showcase all formats together for direct comparison, clarity and interpretability were prioritized by separating them into format-specific graphs. Second, since each respondent could indicate multiple formats for receiving information from a single organization, the resulting network included multiple edges per actor–organization pair. While this reflects the richness of information flows, it also inflated the number of links, leading to dominant visual patterns that may obscure nuance. Third, the current maps lack inter-actor

ties. The current structure focuses on links between actor groups and information sources but does not reflect direct interactions between actor groups themselves. This may limit the interpretation of peer-to-peer knowledge exchange, although it was not the primary focus of the survey design. We welcome a network of this kind for future research. Fourth, the number of listed organizations and how they were categorized varied slightly between countries, which may limit strict cross-country comparison. We have, however, aimed to maintain as much consistency as possible (without being contextually and culturally 'flattening') between countries so as to make for a decent case of comparison between cases. Fifth, to standardize flows across actor categories of varying size, edge weights were normalized by the number of respondents per receiver group. This approach ensures comparability across actor types but may amplify flows from underrepresented categories (e.g., when only three respondents belong to a group). As such, normalized edge strength does not directly reflect absolute frequency, and comparisons should be interpreted as relative flow patterns, not raw interaction volume.

Each country team aimed to sample up to 40 respondents, but the actual number of completed surveys varied. While most samples included actors from government, civil society and private sectors, the exact composition of respondent pools differed, affecting network density and actor visibility. These sampling imbalances limit claims about national representativeness, and findings discussed here should be understood as mapping perceived knowledge exchange among a purposive sample, not a complete census of any kind. All comparisons rest on the seven SNA surveys supplied. Sample sizes differ sharply (n = 18 – 51), and actor groups are unevenly represented, most visibly for local authorities, media, and business. Findings therefore speak to the perceived information landscape among respondents rather than to complete national systems. Where patterns are highlighted below, they are traceable in at least two converging data components (network topology, format-specific flows, chord reciprocity, or the Q9-Q11 exchange conditions).

3 Results

This section presents findings from the SNA conducted across the seven country cases. For each country, we adopt a consistent structure that enables comparative analysis while attending to the contextual nuances of information exchange dynamics related to biodiversity and climate change.

We begin by introducing the demographic and positional characteristics of survey respondents, offering insight into who they are and the types of contributions they make within their organizations, whether as decision-makers, technical experts, or intermediaries. Understanding the professional roles and self-perceived contributions of respondents is essential for interpreting how knowledge circulates through institutional structures.

Following this, we present the Network map, which depicts aggregated, non-directional ties between actor categories. These visualizations are constructed from responses to the question asking from which types of organizations respondents receive information. The diagrams illustrate the density and intensity of information flows between actor groups (e.g., ministries, research institutions, NGOs, private sector), helping us identify central actors, marginal actors, and the overall cohesion of the national information exchange structure. The SNA maps presented for each country illustrate the landscape of biodiversity and climate-related information provision as perceived by national stakeholders. These maps are constructed from survey responses that asked participants to identify which categories of organizations they regularly receive information from, across multiple formats (digital, official, direct). All responses indicating receipt of information from a given organization type are aggregated to build a network of perceived information providers.

In these visualizations, you will see the following:

- Nodes represent organization categories, such as ministries, agencies, NGOs, UN organizations, media, think tanks, and others.
- Node size reflects the total normalized frequency with which that actor group was identified as a source of information. Larger nodes were more frequently cited across the sample.
- Node colour encodes the actor type, based on a consistent set of classifications applied across all countries.
- Edges (links) connect actor groups that were co-selected by respondents, indicating that a respondent listed them as sources of information. These co-occurrence links are weighted by how frequently such combinations occurred, and edge thickness reflects normalized values.
- While the underlying graph is technically directed, the maps are interpreted as undirected visualizations: they do not capture directional flows of information between provider groups themselves, nor do they show peer-to-peer relationships.
- The maps aggregate across all formats (online, official, direct) to provide a holistic view of each actor's visibility as an information provider.

It is important to note that this network structure does not capture nuances of who provided information to whom at the individual level, nor does it reflect frequency of interaction or intensity of engagement. Instead, it provides a relational profile of which actor types are viewed as salient sources of information, and how these perceptions cluster across the respondent base in each country.

Together, these SNA maps help identify key informational actors, underrepresented provider types, and cross-sectoral patterns in how knowledge travels within national climate and biodiversity governance systems. To complement the visual representation of the SNA maps, we computed key network-level and node-level metrics to better understand structural patterns of information provision across actor groups.

These metrics provide quantitative insight into the extent to which specific actor categories are perceived as central sources of biodiversity and climate-related knowledge. Specifically, we report:

a. In-Degree: the number of times an actor category was named as an information provider, reflecting how frequently they are recognized by others in the network.
b. Outgoing Flow (Normalized): the total strength of outgoing ties, adjusted to reflect relative weight per respondent. This captures the volume of information provision across actor types.
c. Betweenness Centrality: a measure of brokerage potential, indicating how often an actor group lies on the shortest paths between others. Higher values suggest a bridging or intermediary role.

At the network level, we also report: i) total nodes and edges, to indicate overall network size, ii) number of isolates, referring to actor groups that were never named as information providers and iii) in-degree centralization, which quantifies how evenly or unevenly centrality is distributed across the network. Higher values indicate that a small number of actors dominate information provision, while lower values suggest a more distributed structure.

We then turn to a set of Sankey diagrams, which allow us to analyse these same information exchanges through the lens of formats of communication. Each Sankey diagram illustrates how information flows from provider categories to recipient categories, disaggregated by format: official (e.g., reports, policy briefs), direct (e.g., meetings, personal communication), and online (e.g., websites, databases). This helps us understand not only who shares information, but how they do so, and whether some formats are associated with specific actor types.

Finally, we present a chord diagram, which reintroduces directionality by showing organization-specific flows within each country. Based on responses to the question asking which organizations respondents received information from and which ones they forwarded information to, this visualization maps individual organizations and the frequency of their connections. The blue ribbons represent received information, while the red ribbons indicate forwarded information. This high-resolution map allows us to identify which organizations are central brokers, net receivers, or active disseminators within national knowledge networks. It also allows us to detect asymmetries in interaction patterns and reflect on the inclusivity, redundancy, or fragmentation of institutional knowledge systems. Through this sequence of visual and interpretive tools, we aim to capture the architecture of national science-policy interfaces, and to interrogate the power dynamics, epistemic roles, and institutional capacities that shape how climate and biodiversity information travels, and where it might stall.

3.1 Armenia

3.1.1 Information on Respondents

In Armenia in total 18 respondents completed the survey. Among respondents in Armenia, the most commonly cited contribution to the provision and transfer of biodiversity–climate information is the provision of technical or professional expertise (reported by 16 individuals), followed by forwarding or communicating internal recommendations (around 8 individuals). Only five respondents indicated that they are directly involved in making decisions that include biodiversity and climate issues. This suggests that the Armenian respondent pool is skewed toward technical experts and communicators rather than high-level decision-makers. It also signals a potential institutional bottleneck between knowledge provision and its uptake in policy or programmatic decisions. For further actor specific distribution see the Appendix.

3.3.2 Network

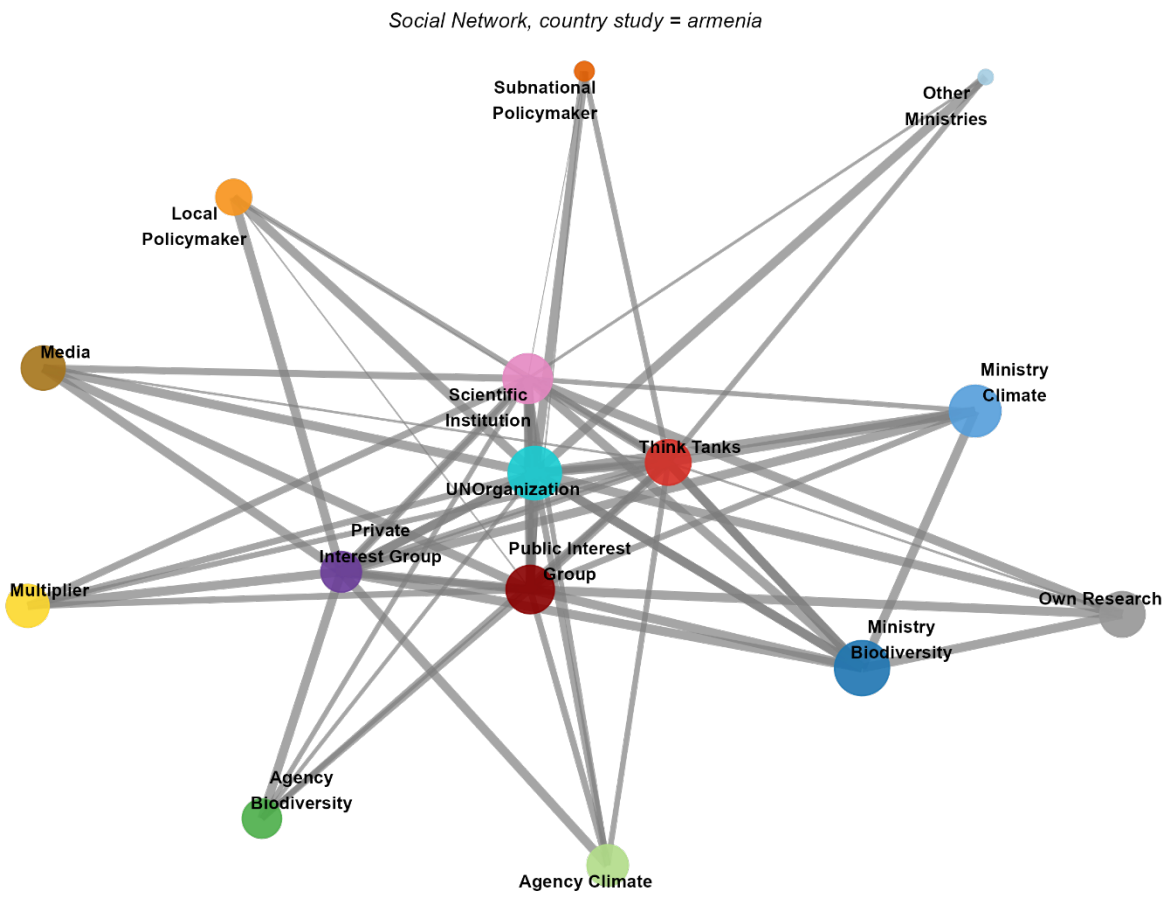

Figure ARM-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Armenia.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	In-Degree	Outgoing Flow	Betweenness
MinistryBiodiv	6	6.00	0.00000

Media	6	5.67	0.00000
MinistryClimate	6	5.35	0.00000
Multiplier	6	4.37	0.00000
PrivateInterestGroup	5	3.97	0.00000
PublicInterestGroup	5	3.12	0.00160
ScientificInst	5	4.80	0.00588
ThinkTanks	5	5.00	0.00588
UN	5	3.68	0.00588
AgencyBiodiv	5	3.52	0.00000
AgencyClimate	5	3.77	0.00000
OwnResearch	5	4.13	0.00000
LocalPolicymakers	4	2.12	0.00000
SubnationalPolicymakers	3	2.07	0.00000

Table ARM-1.

The Armenia network map reflects a dense and highly interconnected national information system, with every actor group named at least three times as a provider (InDegree ≥ 3) and no isolates. This is consistent with the graph-level density and low fragmentation, and aligns with the country's compact institutional geography. According to a local expert familiar with Armenia's environmental governance, this density is not surprising: nearly all relevant institutions are located in Yerevan, the capital, where a small group of professionals—often interconnected across roles and institutions—form the core of national decision-making processes. In terms of structure, the Ministry of Biodiversity, Ministry of Climate, Media, and Multipliers all received six incoming citations, the maximum in this sample. Several others (e.g., Public and Private Interest Groups, UN bodies, Scientific Institutions) follow closely behind with five citations each, indicating a relatively egalitarian distribution of perceived knowledge provision. Outgoing normalized flows range from 2.07 to 6, further suggesting a balanced network without hyper-centralized hubs. In-degree centralization is low (0.048), reinforcing the idea that information sourcing in Armenia is widely distributed across actor types. The roles of Scientific Institutions (Betweenness = 0.00588), UN Organizations (0.00588), and Think Tanks (0.00588) are particularly notable due to their bridging capacity, as captured by non-zero betweenness scores. These actors help connect otherwise separated groups, possibly functioning as translators of global frameworks (e.g., IPBES, IPCC) into national discourse. This is reinforced by contextual information: organizations like WWF and UNDP have operated across Armenia and Azerbaijan, maintaining dialogue where bilateral state cooperation is politically blocked due to historical conflict. Their structural prominence in the network may reflect their unique role in facilitating cross-border or regional information flow, particularly in contested geopolitical contexts. While ministries and government agencies are well-represented in the network (with both biodiversity and climate ministries receiving six citations), local-level actors appear less central. Subnational Policymakers (InDegree = 3) and Local Policymakers (4) are at the lower end of citation frequency, with minimal betweenness, suggesting their limited role in national information dissemination. This structural marginality mirrors the urban–rural divide described by local experts: although strategies are formulated centrally, implementation happens in rural areas where communities often remain disconnected from national-level policy discourse. The expert noted that villagers may not read, access, or be consulted about national strategies, with traditions, local power dynamics, and male-dominated decision-making shaping rural adaptation instead. In such cases, NGOs, not state actors, serve as the key intermediaries with local populations.

Finally, an interesting institutional dynamic is reflected in the case of WWF Armenia, whose current director was, until recently, Armenia's IPBES national focal point. This kind of institutional mobility reinforces the tight-knit, overlapping nature of Armenia's science-policy network, where roles, relationships, and knowledge systems are often embodied in a small number of individuals. In such settings, personal ties may be as important as formal institutional mandates in shaping the flow of biodiversity and climate knowledge. In this sense, Armenia's dense and relatively symmetric information network reflects both the country's

compact institutional geography and the overlapping roles of actors in its environmental governance space. National ministries, civil society, and international organizations are all actively named as providers. However, local-level actors remain peripheral, reflecting implementation gaps and urban–rural disconnects. In conflict-affected contexts like Armenia, NGOs and UN bodies play critical roles in regional knowledge mediation where bilateral state cooperation is politically constrained.

3.1.3 Information Flows

3.1.3.1 Information Flow by Format

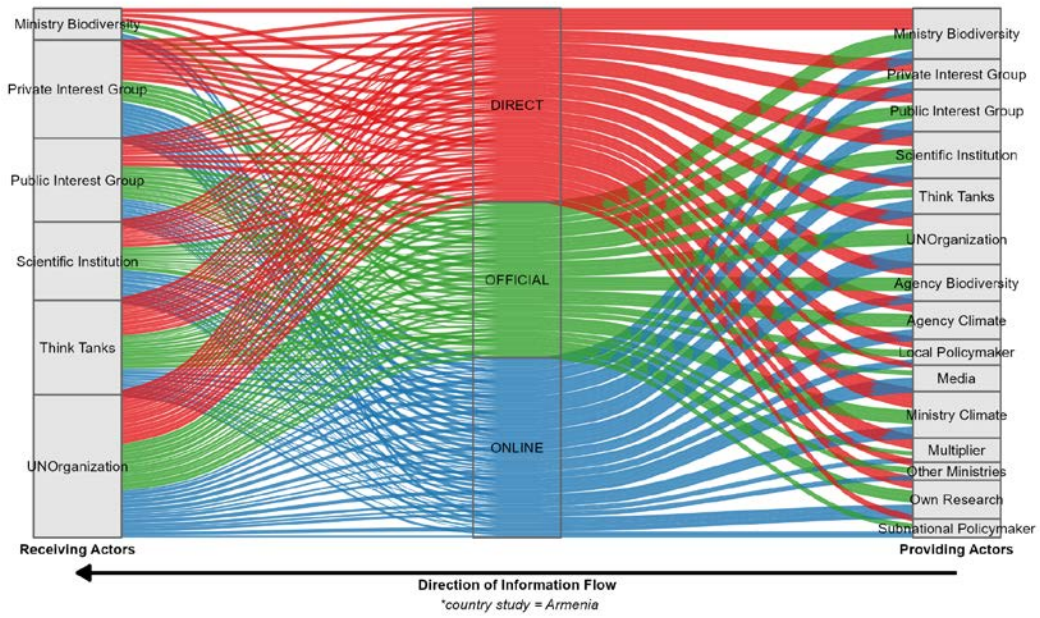

Figure ARM-2. Format-specific Sankey diagram showing how information from providers reaches receivers in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

While all three communication formats—direct, official, and online—are present in Armenia's information landscape, the diagram suggests a slightly higher volume of flows via direct and online formats, with official channels playing a somewhat smaller role in overall information exchange. This distribution reflects a relatively balanced but not equal use of modalities, with a lean towards less formalized or more personalized communication routes. Notably, Private Interest Groups, Think Tanks, and UN Organizations appear to both provide and receive a significant share of their information via direct communication, highlighting the importance of personal networks and established relationships in the Armenian science-policy interface. This pattern may reflect the relatively small size of the national climate and biodiversity policy community, where actors are well-connected and rely on interpersonal or semi-informal modes of exchange. The relatively strong presence of online communication, especially among actors like media, own researchers, and some subnational policymakers, may also point to the increasing role of open-access or digitally mediated information flows. However, the comparatively lower volume of official communication suggests that institutionalized, formal dissemination mechanisms may be underutilized, potentially limiting transparency or systematic uptake of evidence in policy processes.

3.1.3.2 Receiver-Specific Information Flow

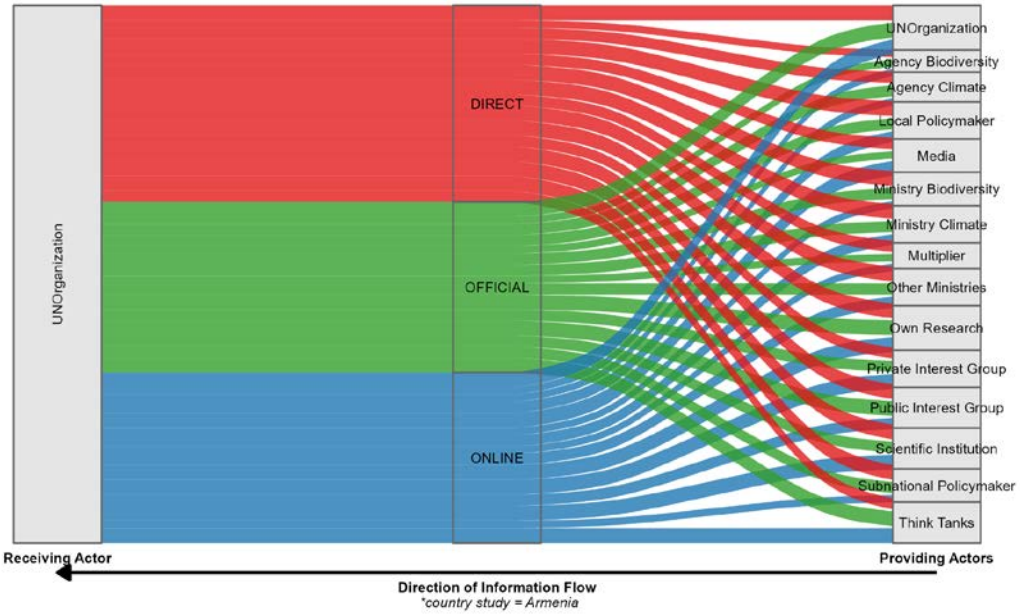

Figure ARM-3. Receiver-Specific (UN Organizations) Information Flow in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

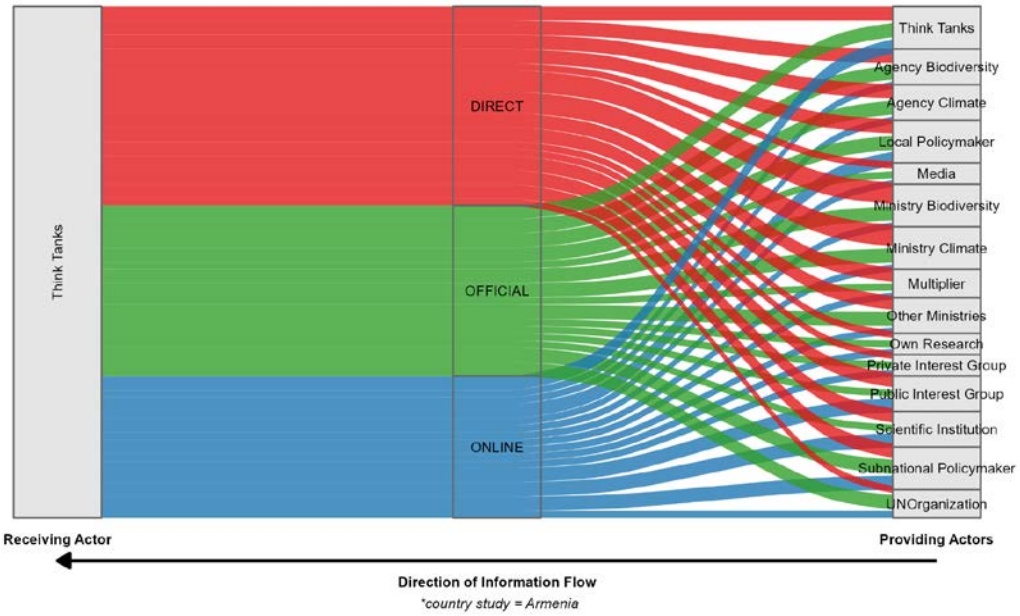

Figure ARM-4. Receiver-Specific (Think Tanks) Information Flow in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

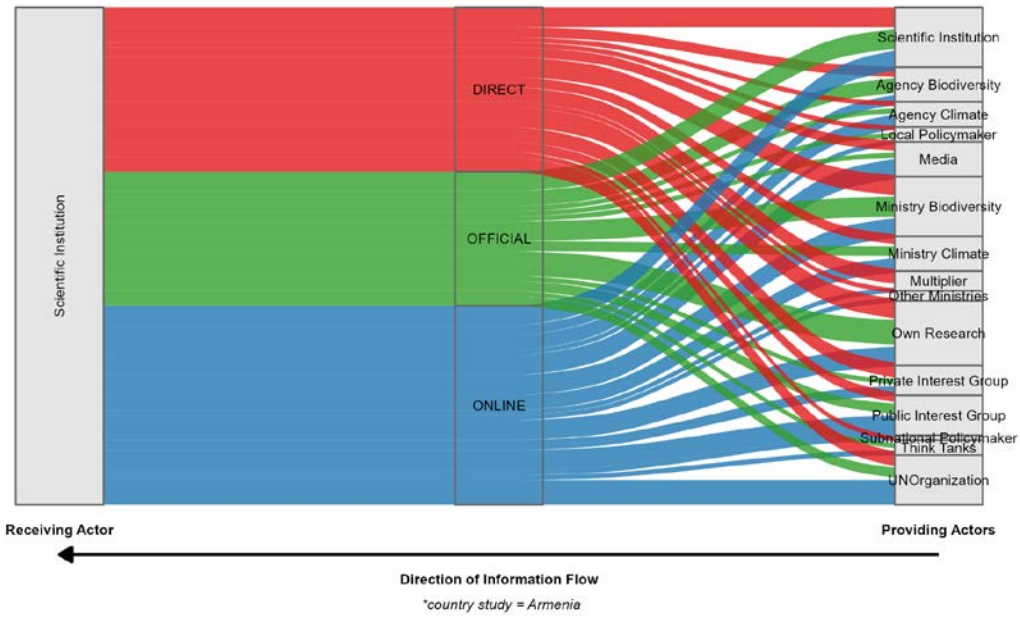

Figure ARM-5. *Receiver-Specific (Scientific Institution) Information Flow in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).*

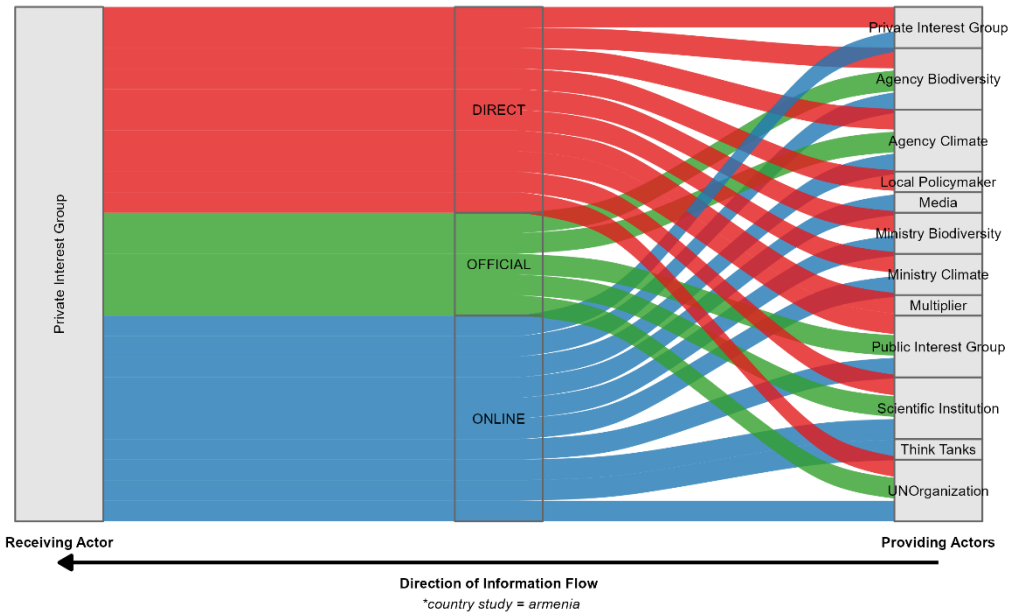

Figure ARM-6. Receiver-Specific (Private Interest Group) Information Flow in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

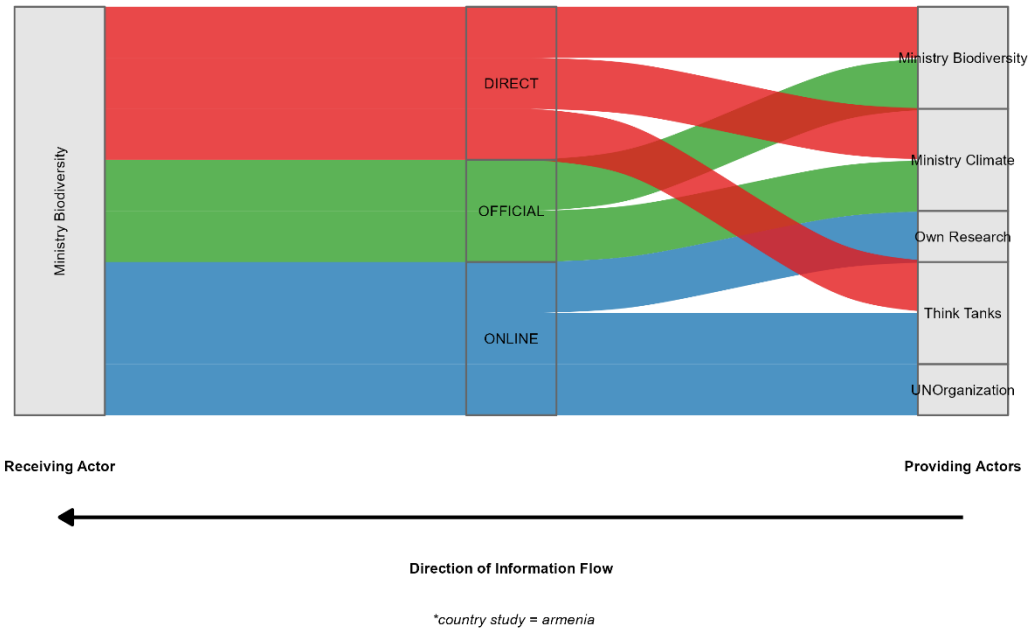

Figure ARM-7. Receiver-Specific (Ministry responsible for Biodiversity) Information Flow in Armenia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities

In Armenia, the Ministry of Biodiversity shows a clear preference for direct communication as the primary format of information exchange. The Sankey diagrams confirm that direct flows between these ministries of biodiversity and climate are particularly prominent, reflecting a pattern of internal coordination between national policy bodies. We also see that international and intermediary actors are working closely with regional governance actors, likely in the context of capacity-building, program delivery, or localized implementation support.

III. Interest and Advocacy Groups

Public interest groups in Armenia exhibit broad engagement across the network, with a notable preference for direct and online formats. They maintain mutual information exchange with other public interest groups, scientific institutions, and think tanks, reflecting their position within a densely connected civil society cluster. Direct communication is especially prominent among these exchanges, suggesting a horizontal and trust-based mode of knowledge sharing within the non-governmental sector. Private interest groups, by contrast, are less prominent as information providers. The Sankey diagrams show fewer and thinner outgoing flows, particularly compared to their public advocacy counterparts. Notably, scientific institutions are among their few receivers, indicating occasional transfer of technical or implementation-related information from private to academic sectors, but limited systemic influence.

IV. Knowledge Intermediaries

Think tanks in Armenia function as key knowledge intermediaries, maintaining reciprocal flows with other think tanks and extending information to both the political and academic spheres. Their reliance on all three communication formats, with visible use of direct and official channels, confirms their role as bridges between sectors, rather than isolated expertise hubs. Media institutions, while not structurally dominant, appear as important information providers to scientific institutions and to both private and public interest groups. The flows suggest that media content contributes meaningfully to civil society and research knowledge pools, although political actors are not listed as recipients, which may point to a lack of feedback mechanisms from public discourse to policy.

V. International and UN Organizations

UN organizations are well integrated within the Armenian network, but their influence appears self-contained or indirect. The diagrams show that political institutions do not receive information directly from UN organizations, suggesting that engagement with ministries or agencies is either absent or not perceived by respondents. Instead, UN organizations have robust internal flows and direct ties to private interest groups, which may reflect project-level coordination or program delivery mechanisms. The flows also show regular use of official and online formats. Collectively, these patterns suggest that UN organizations are active nodes of exchange, but are not embedded within Armenia's core science–policy apparatus, functioning more as autonomous or sectorally targeted actors.

3.1.3.3 Links between Organizations

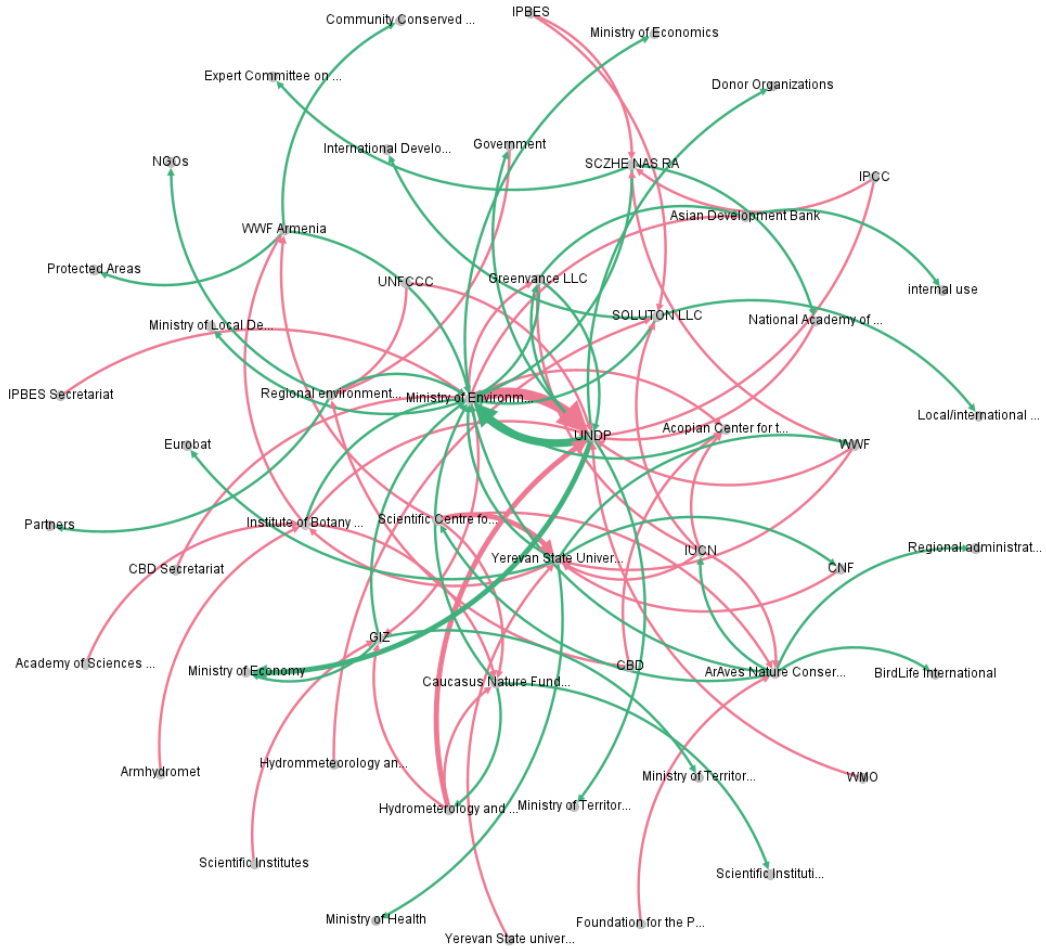

Figure ARM-8: Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.

This figure presents a simplified Social Network Analysis (SNA) of directed information exchange in Armenia's biodiversity–climate knowledge system. It is based on survey responses to a specific question set asking participants to identify which organizations they send information to and receive information from on climate and biodiversity issues. Nodes represent actor organizations or categories, and arrows indicate the direction of information flow. The layout reveals a compact but asymmetrical network, dominated by national ministries, research institutes, and international science bodies. The Ministry of Environment is clearly the most central and multifunctional actor, cited frequently as both a provider and recipient of information. This confirms its position as a key broker in Armenia's knowledge system, a node of consolidation as well as a target for outreach from NGOs, scientists, and multilateral bodies.

Scientific institutions such as the Scientific Centre for Zoology and Hydroecology, the Institute of Botany, and the Hydrometeorology and Monitoring Center are frequently cited as knowledge providers, but appear less often as recipients, indicating a one-directional flow from science to policy rather than iterative exchange. International platforms like IPCC, IPBES, CBD, and IUCN are cited almost exclusively as outward-facing providers, reinforcing their authoritative role in shaping national agendas, but also highlighting the lack of feedback loops that might enable adaptation or contextualisation.

A few organizations, such as WWF Armenia and UNDP, appear in both sending and receiving roles, suggesting intermediary or bridging functions — though their lower degree centrality reflects modest reach. Sectoral ministries such as Economy, Health, and Finance tend to appear as passive recipients, suggesting they are perceived as relevant targets for influence but not active contributors to the national knowledge system.

Overall, the network is vertically structured and institutionally concentrated, with a strong emphasis on global expertise and national technical bodies. However, the absence of strong horizontal ties or mutual exchange suggests limited space for cross-sectoral deliberation, peer learning, or dialogical knowledge integration.

The Armenian knowledge exchange network appears institutionally concentrated and vertically structured. The emphasis on global sources and national science agencies indicates a system likely built on technical credibility, but potentially at the expense of horizontal diversity and iterative learning. While the Ministry of Environment functions as a key broker, the broader structure suggests limited space for peer-to-peer knowledge flows or cross-sectoral deliberation[1].

[1] As in all Other cases, the Armenia survey focused on government, scientific, and selected civil society actors. Academic institutions were not the primary respondents, and private sector actors are underrepresented. Interpretation should therefore focus on mapping known flows among the sampled actor types, not the totality of Armenia's science-policy ecosystem.

3.1.4 Facilitation and Improvement of Knowledge Exchange

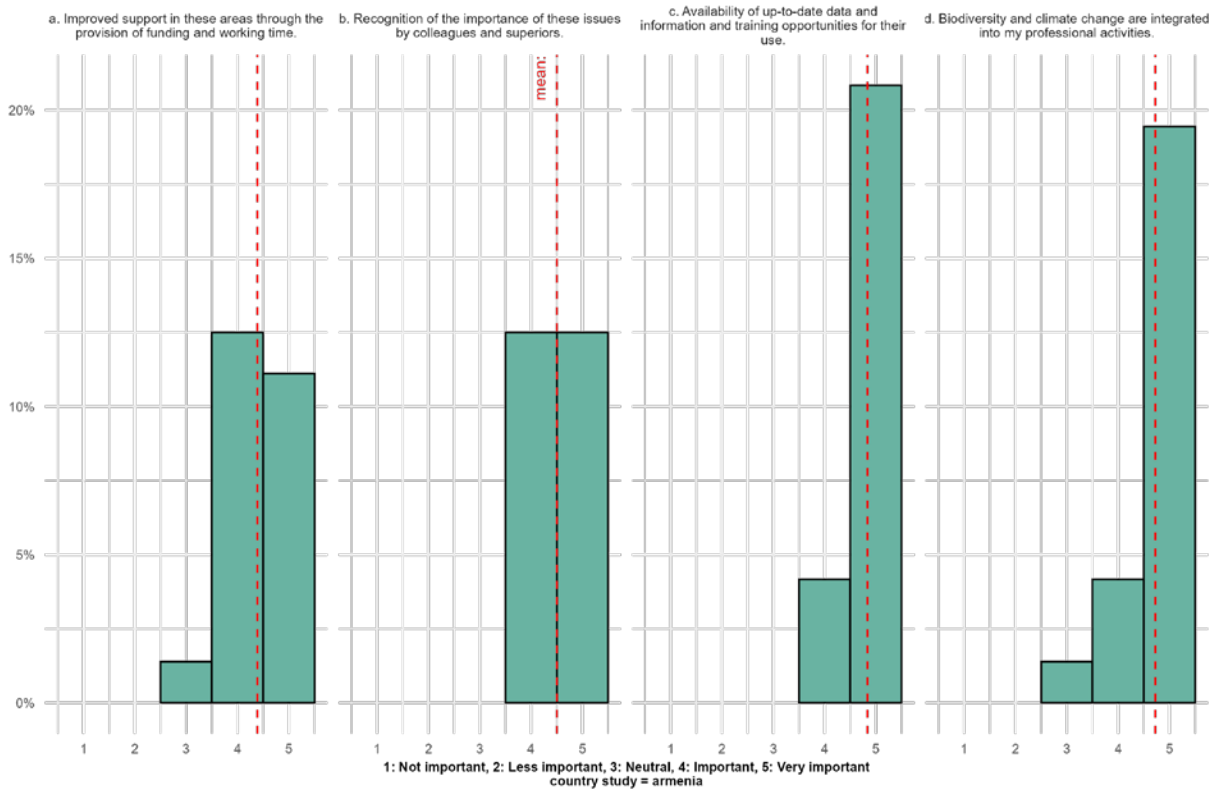

Figure ARM-9: Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

The figure presents response distributions for four statements assessing how well biodiversity and climate knowledge exchange is supported in professional settings. Respondents rated each statement on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Overall, the data indicates consistently high levels of agreement, with mean scores ranging from 4.16 to 4.44, suggesting that most respondents perceive institutional conditions for knowledge exchange to be generally supportive. The highest agreement was recorded for the statement that biodiversity and climate change are integrated into respondents' professional activities (mean = 4.44). While this reflects strong alignment for many, the spread of responses, particularly the presence of lower scores, may indicate that biodiversity and climate concerns are not a core focus for all respondents, especially those working in adjacent or cross-cutting sectors.

The statement regarding the availability of up-to-date data, information, and training opportunities received a mean score of 4.16, the lowest among the four. Although still relatively high, this suggests room for improvement in technical support and capacity-building infrastructure, particularly for respondents who may lack consistent access to relevant resources.

Respondents also expressed strong agreement with the statement that colleagues and supervisors recognize the importance of biodiversity and climate issues (mean = 4.27), highlighting the perceived importance of internal workplace support for engaging with these topics. Lastly, there is high agreement (mean = 4.31) with the need for additional support, including funding and time allocation, to enable deeper engagement in biodiversity–climate work. Taken together, the results point to a generally supportive environment for knowledge exchange in Armenia, but also suggest that institutional integration of these issues is uneven, and that material support and data infrastructure could be further strengthened. While the responses reflect awareness and alignment at the individual and organizational levels, they may also hint at gaps in urgency or systemic prioritization of biodiversity–climate challenges in everyday professional contexts.

Preferences for Strengthening Cooperation and Information Exchange

Access to Knowledge: There is a need for better access to tailored summaries of scientific and technical assessments designed to meet the needs of policymakers. Further, respondents emphasized the importance of data availability and the establishment of a national digital platform for collecting and disseminating relevant information. It was highlighted that besides knowledge generation, sharing information and fostering cooperation is essential.

Connection to the Local and Concrete Level: Need for more data on the national and regional impacts of climate change and biodiversity loss. Complex data must be translated into clear, actionable insights to support both policymakers.

Bridging Science and Policy: Regular platforms for dialogue (e.g. science-policy forums and advisory committees) between different stakeholders.

Political Decision-Making Capacity: Transparency, dedicated financial resources for research, and targeted training programs for high-level decision-making bodies are seen as essential to enable evidence-based political action on climate and biodiversity.

Public and Cross-Sectoral Awareness: Efforts should be intensified to raise awareness of the connections between climate change and biodiversity loss, especially regarding their impacts on other sectors. This applies to both the general public and professionals across disciplines.

Respondents expressed a strong interest in enhancing cooperation with a diverse range of organizations across political, scientific, and international domains. Within the category of national and international political bodies, the institutions most frequently mentioned included the Ministry of Finance, the Ministry of Environment, various national-level agencies, and foreign governments, particularly those of the European Union and the United States. These entities were seen as key partners for advancing integrated biodiversity and climate policy efforts. In the realm of international organizations, respondents highlighted a desire to strengthen ties with UNEP, IUCN, CBD, and the IPBES. These organizations were recognized not only for their convening power but also for their role in shaping global science-policy agendas. Regarding the scientific sector, respondents expressed interest in closer collaboration with national research institutes. Specific institutions mentioned include the State Monitoring Centre, the Hydrometeorology and Monitoring Center, the National Academy of Sciences, the Institute of Botany, and the Scientific Centre of Hydrogeology and Zoology. These entities were viewed as crucial providers of technical data and analytical capacity. Importantly, respondents emphasized that the preferred formats for cooperation and communication depend significantly on the topic and policy context. While no single format was uniformly favoured, respondents noted that the appropriateness of direct, official, or online communication is highly contingent on the urgency, scale, and institutional scope of the issue at hand.

3.2 Colombia

3.2.1 Information on Respondents

In Colombia in total 23 respondents completed the survey. The most frequently reported contribution among Colombian respondents is the provision of technical or professional expertise to inform decision-making (checked 20 times in the questionnaire). This suggests a strong representation of actors with specialized knowledge and analytical capacities, possibly from scientific institutions, public agencies, or consultancies. Communication and forwarding of internal recommendations also feature prominently (checked 13 times in the questionnaire), indicating that a sizable share of actors serve as intermediaries who help circulate information within their organizations. Direct decision-making roles are the least commonly reported (checked 7 times in the questionnaire), implying a relatively limited presence of formal decision-makers among respondents. For further actor specific distribution see figure XX in the Appendix.

3.2.2 Network

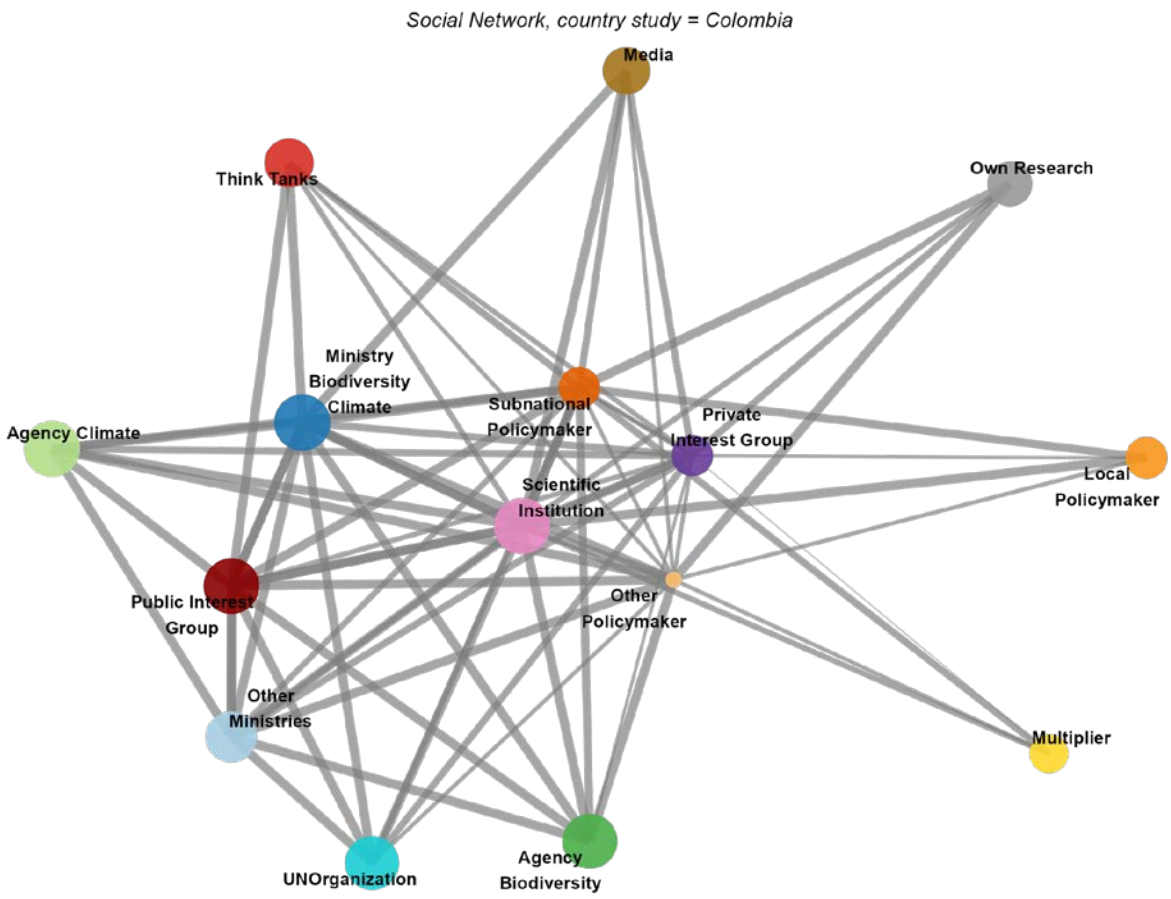

Figure COL-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Colombia.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	InDegree	OutgoingFlow	Betweenness
MinistryBiodiversityClimate	7	6.8	0.00733
PublicInterestGroup	7	6.6	0.00458

ScientificInstitution	7	6.8	0.0925
AgencyBiodiversity	7	6.3	0
AgencyClimate	7	6.7	0
UNOrganization	7	6	0
OtherMinistries	6	5.17	0
ThinkTanks	6	4.57	0
Media	5	4.1	0
PrivateInterestGroup	4	2.7	0
SubnationalPolicymaker	4	2.7	0
LocalPolicymaker	4	2.8	0
Multiplier	4	2.17	0
OwnResearch	4	3.47	0
OtherPolicymaker	0	0	0

Table COL-1

Metric	Value
Number of Nodes	15
Number of Edges	79
Number of Isolates (in=0)	1
In-Degree Centralization	0.124

Table COL-2

The Colombian SNA reveals a relatively balanced structure of biodiversity–climate knowledge exchange, with a range of governmental and non-governmental actors occupying central positions as perceived information providers. The network consists of 15 actor categories and 79 directed ties, with only one isolate ("Other Policymaker"), an actor type not mentioned by any respondent as a source of information.

Six actor groups share the highest in-degree centrality (value of 7), indicating that they were each named most frequently as providers of biodiversity–climate information: Ministry of Biodiversity and Climate; Scientific Institutions; Public Interest Groups; Agency for Biodiversity; Agency for Climate, and UN Organizations. These actors are recognized across multiple respondent categories, suggesting a multi-source knowledge landscape in which governmental, scientific, and civil society organizations all play active roles.

When examining normalized outgoing flow, a measure of the total information volume reported as received from these actors, the Ministry of Biodiversity and Climate and Scientific Institutions are tied at the top (6.8), followed closely by the Climate Agency (6.7) and Public Interest Groups (6.6). These values reflect not only the frequency of citations but also the breadth of recognition across respondent types. Importantly, Scientific Institutions combine both high flow and the highest betweenness centrality (0.0925), indicating a modest but notable bridging role in the network. While betweenness values are generally low across all nodes, suggesting limited intermediation between otherwise disconnected actors. Scientific Institutions stand out as a connective hub within this relatively flat structure.

The network's in-degree centralization score of 0.124 confirms a moderately decentralized configuration: knowledge provision is not dominated by a single actor group, but distributed among several key providers. This may suggest an institutional environment with multiple, concurrently relevant sources of information.

At the network's periphery are actor groups such as Private Interest Groups, Local and Subnational Policymakers, and Multipliers. These categories have lower in-degree scores and minimal flow values, indicating they are less frequently named as information sources. Their inclusion in the network nonetheless points to a diversified field of knowledge exchange, even if their current roles are more marginal. The sole isolate, "Other Policymaker," reflects either limited visibility in national biodiversity–climate knowledge flows or a potential ambiguity in how respondents interpreted this category.

Qualitative observations of the Colombian network map align with these metrics. Several ministries, particularly the Ministry of Environment and Sustainable Development (MADS), exhibit substantial node sizes and thick outgoing ties, highlighting their central role as information providers. Scientific Institutions and Public Interest Groups also appear prominent, connecting with a wide array of recipients. Other sectoral ministries (e.g., Mines and Energy, Agriculture) and civil society actors are present but slightly less central, while Private Interest Groups and Think Tanks remain peripheral.

The relatively even distribution of ties and the presence of both governmental and non-governmental actors in central positions point to a functional and moderately pluralistic science-policy interface. However, the generally low betweenness values across the network suggest limited cross-sectoral brokerage or integrative coordination. Future research could explore whether this pattern reflects institutional pluralism (i.e., deliberate decentralization) or fragmentation in knowledge uptake processes.

3.2.3 Information Flows

3.2.3.1 Information Flow by Format

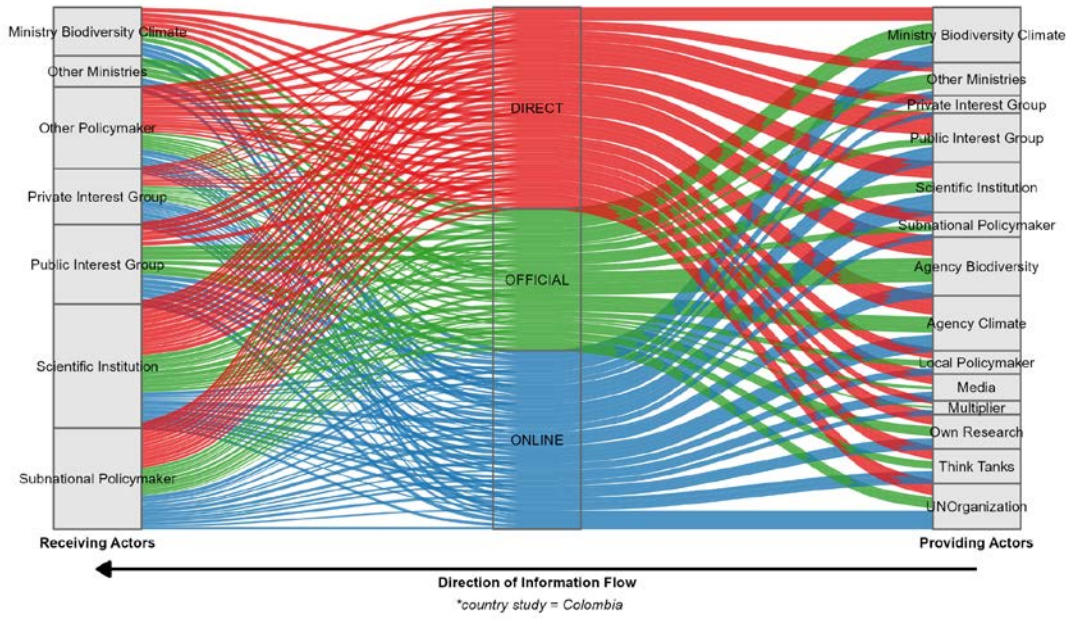

Figure COL-2. Format-specific Sankey diagram showing how information from providers reaches receivers in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

The Sankey diagram for Colombia reveals a diversified and multi-directional knowledge exchange structure, where nearly all actor categories function as both information providers and recipients. Three primary communication formats, direct, official, and online, are used extensively across the network, with direct exchange emerging as the most dominant, particularly between political institutions, agencies, and civil society actors.

Direct communication (red flows) constitutes the most visually prominent channel of exchange. It is especially prevalent between ministries, national agencies, public and private interest groups, and scientific institutions, suggesting a relationally intensive and often informal dimension of knowledge sharing. This mode is widely used not only between state actors but also across civil society and technical communities, pointing to a governance culture that values personalized interaction and institutional proximity.

Official formats (green flows) are widely used by governmental actors, including the Ministry of Biodiversity and Climate, Agency for Climate, and other ministries, as both providers and recipients. These flows highlight the role of formalized, procedural information exchange, likely through documentation, reports,

or inter-institutional memoranda. Official communication also features prominently in the exchanges with scientific institutions and public interest groups, indicating that evidence-based materials are often shared through institutionalized channels.

Online communication (blue flows) is strongly present in interactions involving scientific institutions, UN organizations, multipliers, and to a lesser extent, subnational and local actors. These digital or asynchronous exchanges suggest a reliance on publicly accessible platforms, data repositories, or electronic communication, especially among international bodies and knowledge intermediaries. While less visually dominant than direct exchange, online formats contribute significantly to the breadth and reach of the network, extending knowledge access beyond core governmental circles.

Overall, the diagram illustrates a highly interconnected and format-diverse knowledge ecosystem. Political actors, especially ministries and agencies, are positioned at the center of both giving and receiving flows, while scientific institutions and public interest groups bridge technical and societal domains. The relative balance across the three formats implies that stakeholders adapt their communication strategies based on the audience, institutional relationship, and topic at hand.

3.2.3.2 Receiver-Specific Information Flow

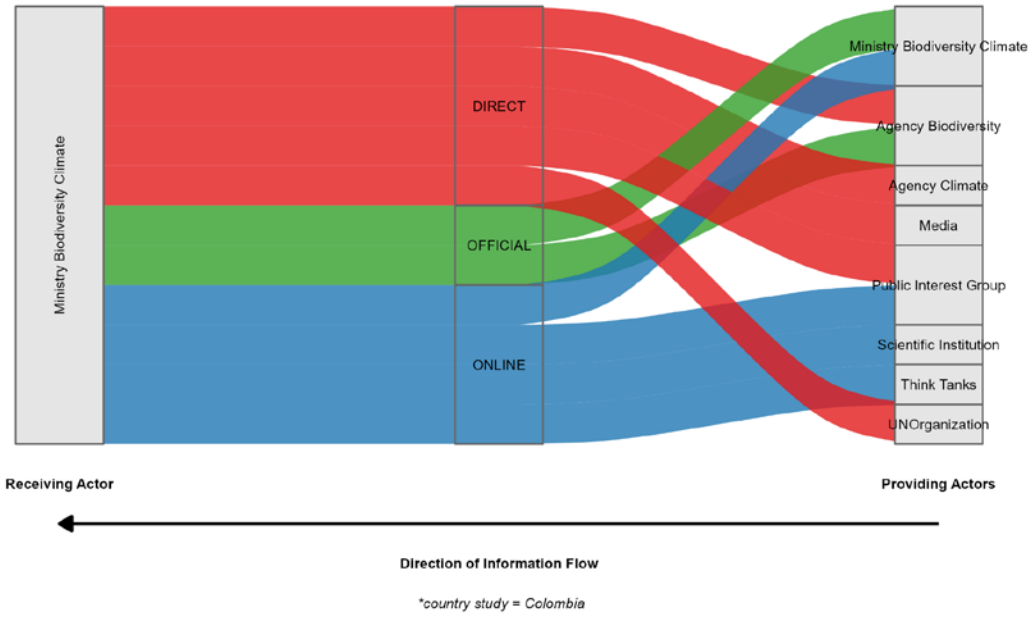

Figure COL-3. Receiver-Specific (Ministry responsible for Biodiversity and Climate) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

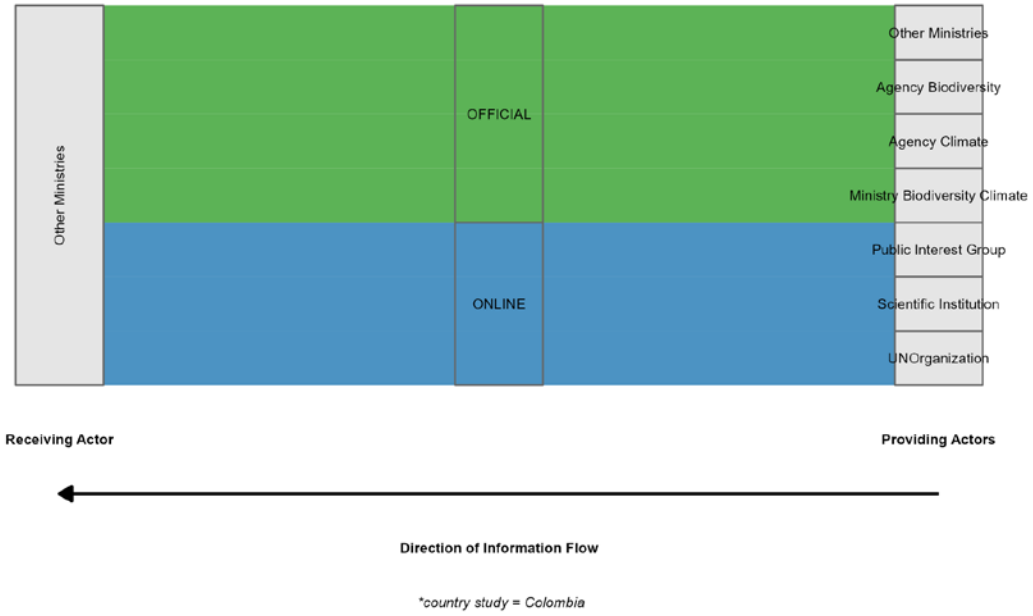

Figure COL-4. Receiver-Specific (Other Ministries) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

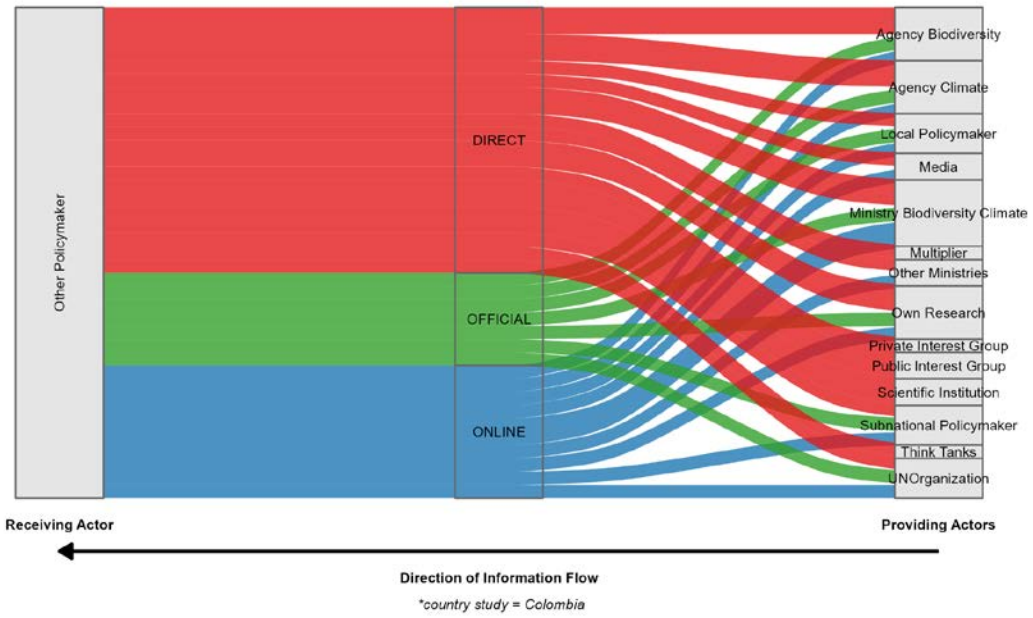

Figure COL-5. Receiver-Specific (Other Policymakers) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

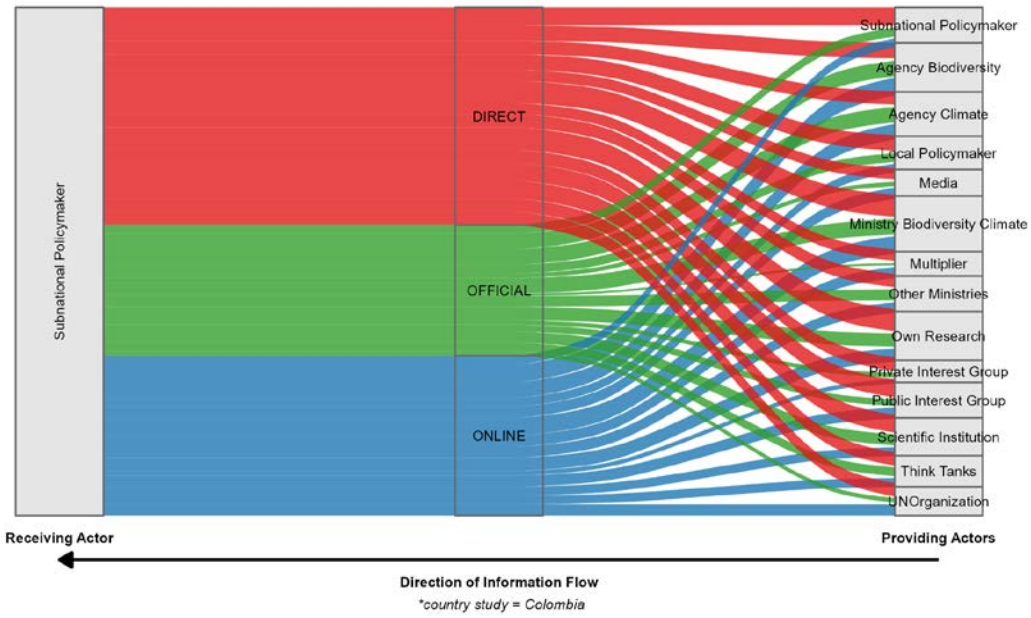

Figure COL-6. Receiver-Specific (Subnational Policymaker) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

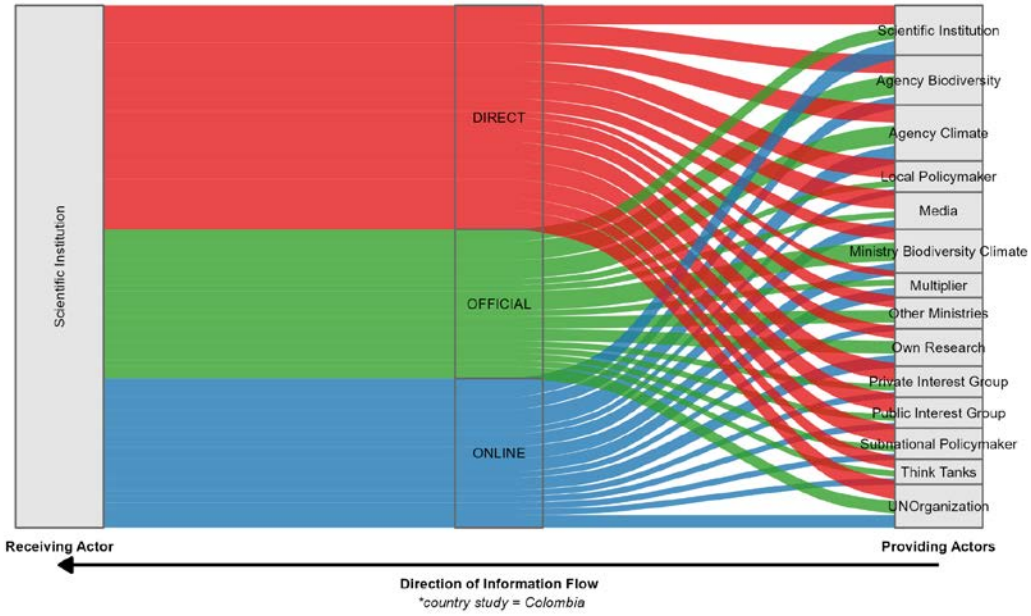

Figure COL-7. Receiver-Specific (Scientific Institution) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

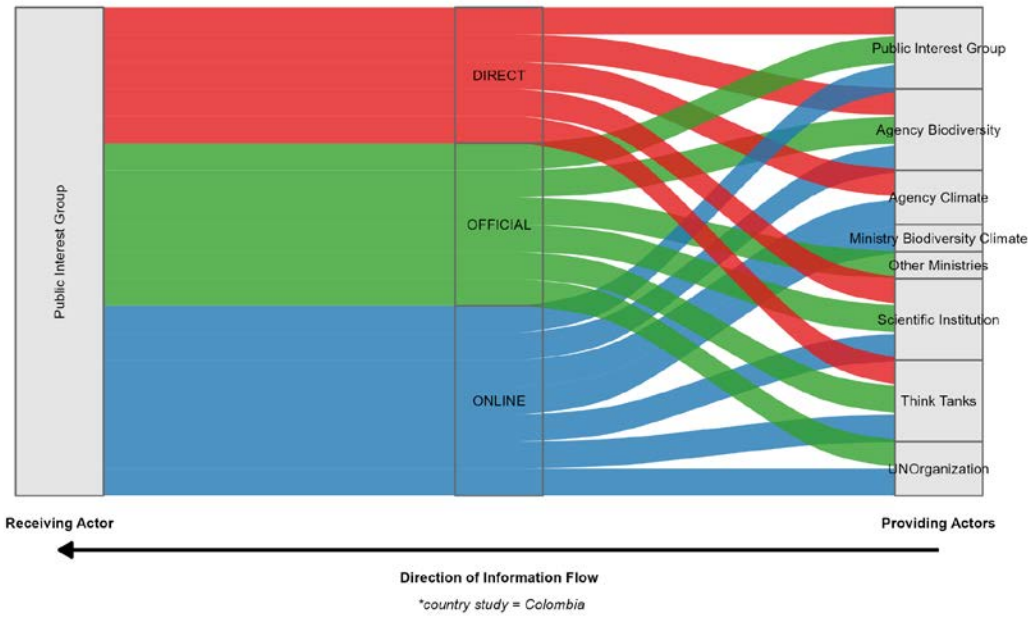

Figure COL-8. Receiver-Specific (Public Interest Group) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

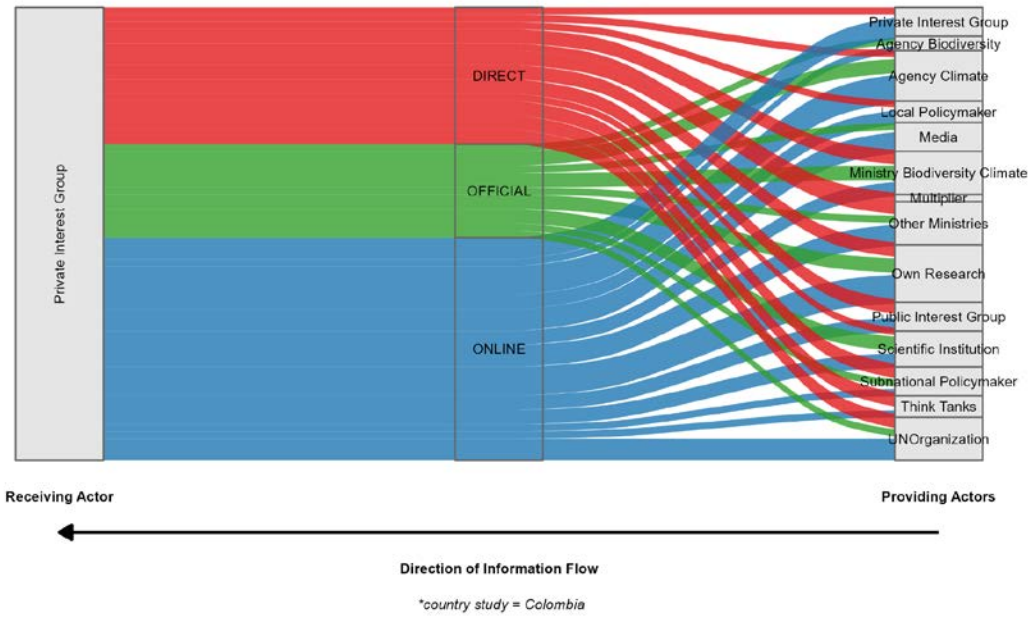

Figure COL-9. Receiver-Specific (Private Interest Group) Information Flow in Colombia, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities

In Colombia, public authorities, particularly the Ministry of Biodiversity and Climate, receive information from a broad array of providers, including agencies, civil society actors, and scientific institutions. The

dominant mode of communication is direct exchange, though official and online formats are also visible. The Ministry's receiving flows are particularly strong from the Media, Scientific Institutions, and Public Interest Groups, suggesting that it integrates both technical and societal sources into its knowledge intake. Other ministries rely less on direct engagement and more heavily on official and online formats, particularly from fellow ministries, public agencies, and scientific organizations. This indicates a more bureaucratic or document-based form of knowledge reception. Notably, the diagrams show a high degree of information flow between agencies and ministries, reflecting Colombia's relatively coordinated governmental communication landscape.

II. Scientific and Research Actors

Scientific institutions in Colombia receive biodiversity–climate information through all three communication formats, with a notable preference for online and direct channels. They are strongly connected to ministries, public agencies, and interest groups, indicating that they act as both technical recipients and potential intermediaries. The diversity of sources feeding into scientific institutions, including the Ministry of Biodiversity and Climate, Think Tanks, and UN Organizations, reinforces their role within the broader knowledge ecosystem. The inclusion of online formats suggests an openness to formalized but indirect knowledge circulation (e.g., policy briefs, datasets). Multipliers provide information to actors such as scientific institutions, ministries, and interest groups. This confirms their typical function: hands-on translation of knowledge, likely through targeted engagements like training or workshops.

III. Interest and Advocacy Groups

Public interest groups are prominent receivers of information, particularly from public institutions like Agency for Biodiversity, Agency for Climate, and Scientific Institutions. They obtain information across all three formats, with a slight emphasis on direct and online communication. This reflects their position as active intermediaries who both absorb and repackage information for broader advocacy or outreach. Notably, Think Tanks and UN Organizations also contribute to their information intake, which suggests that public interest groups serve as a convergence point for civil society and technical expertise.

Private interest groups receive information from a wide range of providers, including ministries, agencies, and scientific bodies, mostly via direct and online formats, with official communication being less prominent. This pattern suggests that their inclusion in national information flows is more relational or project-based rather than procedural or institutional. Their strong links with Scientific Institutions and UN Organizations may reflect collaboration on implementation or technical support, but overall, they appear less central than their public counterparts.

IV. Knowledge Intermediaries

Think Tanks in Colombia are connected to a wide array of providers, including scientific bodies, public interest groups, and ministries, with the direct format dominating their intake. They also receive information from UN Organizations, signalling their role in integrating international perspectives into national debates. The diversity and balance of sources suggest that Think Tanks function as strategic intermediaries, absorbing information from both domestic and international arenas to influence discourse or advise policy.

The Media receive information primarily through direct communication, with less use of official or online formats. Their strongest links are with ministries, agencies, and scientific institutions, implying that they play a critical role in translating state and expert knowledge into public discourse. The diagrams do not show political institutions as recipients from the media, reinforcing that the media's role is more outward-facing rather than integrative within the formal policy system.

V. International and UN Organizations

UN Organizations are significant recipients of biodiversity–climate information in Colombia, drawing from nearly every other actor group. Their incoming flows are evenly distributed across direct, official, and online formats, confirming their role as cross-cutting knowledge aggregators. Interestingly, ministries and public

agencies are prominent providers to UN bodies, which suggests that Colombia's international actors are actively informed by national policy developments. However, the UN does not appear to provide information back to ministries in this visualization set, this may reflect a lack of bidirectional policy engagement or that such flows are mediated through civil society or intermediaries like Think Tanks.

3.2.3.3 Links between Organizations

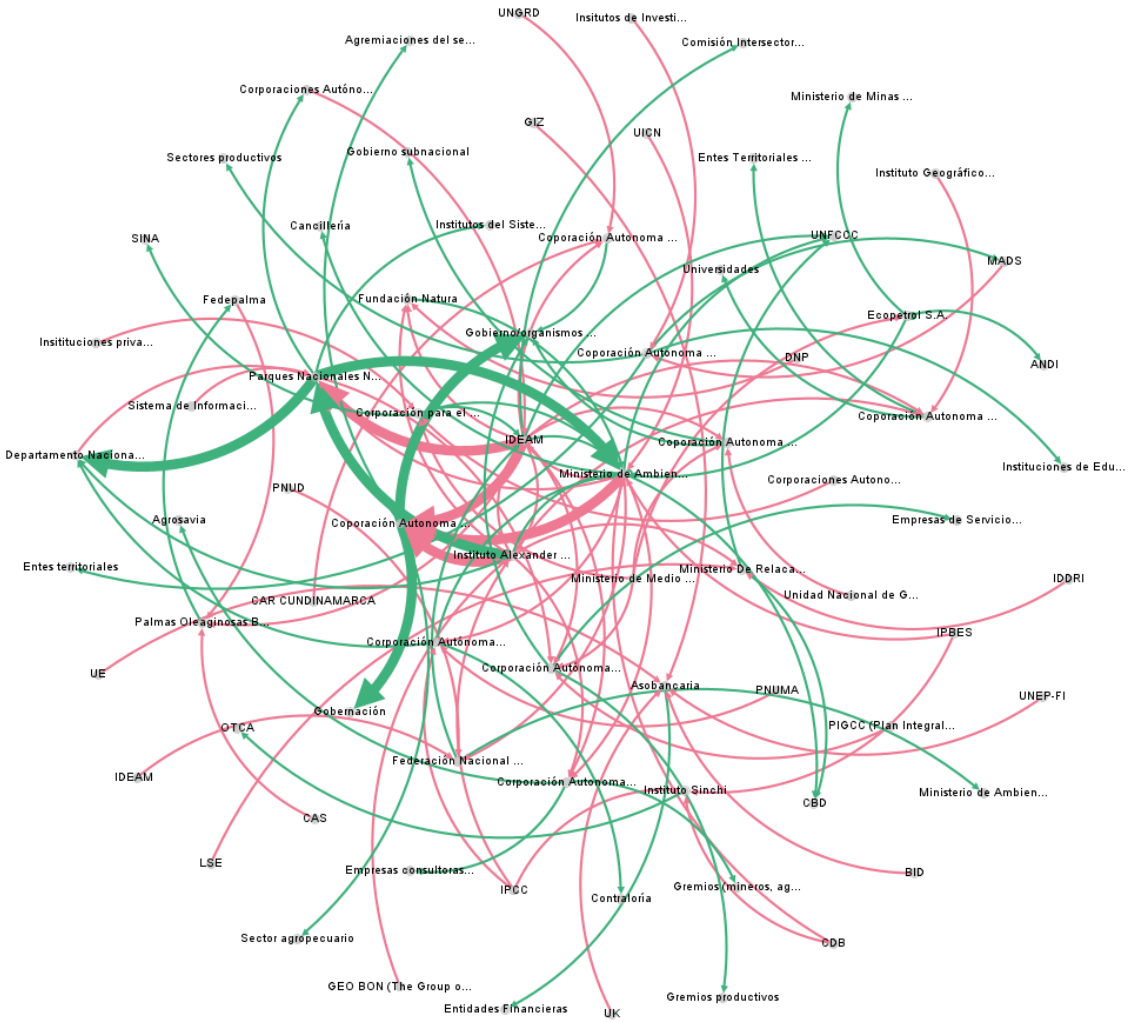

Figure COL-10: *Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.*

This network map visualizes the directionality of information exchange among surveyed organizations in Colombia's biodiversity–climate knowledge system. Arrows represent reported information flows; edge thickness reflects normalized frequency. The map focuses on organizational-level interactions, showing how knowledge is circulated, relayed, or concentrated within the national science-policy interface.

The network exhibits a hybrid-core configuration, with two primary hubs: The Ministry of Environment and Sustainable Development (MADS) stands out as a multifunctional actor, prominently cited as both a

recipient and a provider. It functions as a broker between scientific producers, implementing agencies, and sectoral ministries, which is consistent with its national coordination role. The IDEAM (Instituto de Hidrología, Meteorología y Estudios Ambientales) appears as a dominant knowledge provider, receiving relatively few incoming edges. Its strong outward flow reflects its position as Colombia's main environmental data authority, indicating a scientific but not deliberative nature in its network posture.

The Instituto Alexander von Humboldt also contributes substantially to knowledge provision but remains less central than IDEAM. In the SNA, it is linked to both national agencies and technical actors, suggesting a supporting role in biodiversity-related expertise, albeit with more limited circulation or brokerage function. The organization-specific map highlights the presence of regional and decentralized actors, especially the Corporaciones Autónomas Regionales (CARs), Parques Nacionales Naturales, and various local governments, many of whom appear as recipients of forwarded information. While their position is more peripheral, their inclusion signals an aspirational or implementation-facing layer in the national system, indicating a desire for information to reach territorial actors, even if feedback loops remain underdeveloped.

International platforms such as IPCC, CBD, UNFCCC, and UNDP appear as outgoing-only nodes, reflecting their influence as external knowledge sources. These organizations are integrated into the Colombian system via IDEAM, MADS, and donor-implementing intermediaries (e.g., PNUD, GIZ), but the absence of incoming flows indicates limited formal mechanisms for institutional feedback or dialogue.

The private sector, including Ecopetrol, Federación Nacional de Cafeteros, and agro-business actors is visible but largely situated as recipients rather than contributors. This positioning aligns with stakeholder perceptions of their relevance for outreach or implementation, but not as sources of expertise.

The academic sector remains notably underrepresented in this visualization. While a few universities and research consortia are included, they occupy peripheral positions and exhibit few ties. This points to a specialized research infrastructure (centered on IDEAM and von Humboldt) but thin linkages with broader higher education institutions or interdisciplinary academic networks.

Overall, the Colombia network shows a functionally differentiated but hierarchically structured system, with technical agencies generating science, the environment ministry directing policy coordination, and decentralized actors positioned at the system's edge. While there is evidence of bidirectional exchange at the core, horizontal integration and territorial feedback mechanisms remain limited, constraining the system's adaptive capacity[2].

[2] As in the other six country cases, this analysis is based on a targeted sample of respondents from government, civil society, and scientific institutions. While the data reflect real perceptions of knowledge exchange, they may have underrepresented academia, media, and business actors not included in the original sampling frame.

3.2.4 Facilitation and Improvement of Knowledge Exchange

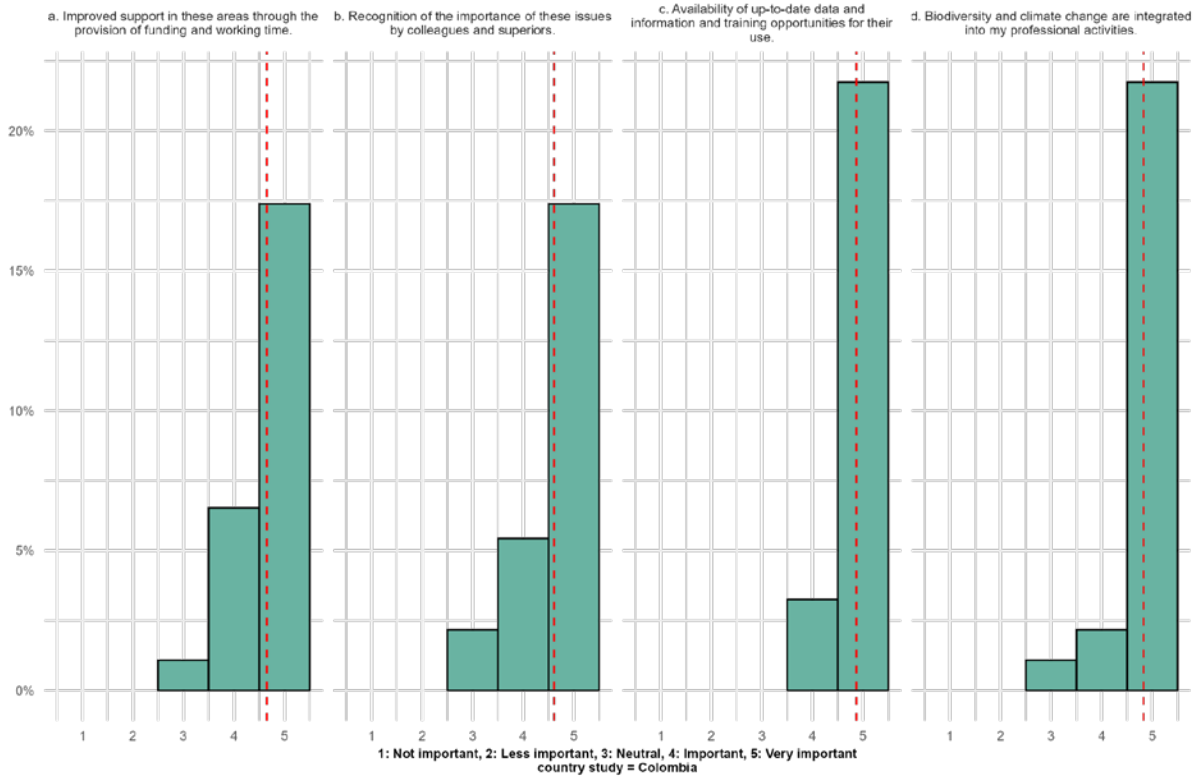

Figure COL-11: Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

The figure displays respondent agreement with four statements regarding the institutional conditions for biodiversity–climate knowledge exchange in Colombia. Agreement levels are high across all items, with mean scores ranging from 4.61 to 4.87, indicating a generally favourable perception of professional support, data access, and integration of climate and biodiversity concerns into respondents' work.

The highest agreement was recorded for the statement on the quality and availability of up-to-date data, information, and training opportunities (mean = 4.87). This suggests that respondents place a high value on knowledge infrastructure but may also be signalling that such resources are not universally accessible. The strong support for this statement could reflect a recognized need for more consistent and inclusive training mechanisms, particularly for non-central actors or those working at implementation levels.

Similarly, respondents strongly agreed with the statement that biodiversity and climate change are integrated into their professional activities (mean = 4.83). This high score may appear counterintuitive, but it likely reflects that many respondents currently work in roles that are explicitly focused on these issues. At the same time, it underscores a structural gap—namely, that many positions in other institutions or sectors may still exclude biodiversity–climate considerations from their formal mandates. This highlights the need to mainstream these issues into a broader range of institutional functions and job profiles.

Agreement is also high for the need for recognition and support by colleagues and supervisors (mean = 4.61) and for institutional support via funding and time allocation (mean = 4.65). These responses suggest that, while respondents may be motivated to act, the enabling environment within institutions remains critical to sustaining meaningful engagement with biodiversity and climate change.

In sum, the results from Colombia indicate that the foundations for effective knowledge exchange are strong among the respondents surveyed. However, the high levels of agreement likely reflect both

acknowledgment of importance and a recognition of ongoing limitations, particularly around data accessibility, institutional mandates, and sector-wide training and integration efforts.

Preferences for Strengthening Cooperation and Information Exchange

In terms of how to facilitate knowledge-uptake, we found the following patterns from responses:

First, it is essential to generate key messages aligned with the design and implementation of public policies at national, sub national, and local levels. Establishing a baseline of knowledge about the synergies, relationships, and impacts of climate change on biodiversity and ecosystem services is a priority. This should be complemented by regional and local studies.

Second, there is a need to promote capacity building for decision-makers on how to use tools like IPBES transformative change scenarios and IPCC climate scenarios, supported by communication campaigns.

Third, information should be centralized and made accessible through interconnected platforms or online portals, as it is often scattered or unknown. The National Environmental System (SINA) should host a thematic online repository linking relevant sources and data from different institutions, strengthening the interdisciplinary nature of environmental issues.

It is also critical to improve institutional coordination. Currently, there is fragmentation among research institutes, Regional Environmental Authorities (CARs), and private entities, leading to inconsistent data and disjointed decision-making. There should be inter-institutional alignment and information sharing. Moreover, efforts must be made to ensure that information is accessible, understandable, and usable by various stakeholders, from policymakers to the general public. This includes developing communication products tailored to different audiences, using clear language, and leveraging digital technologies and social media to increase reach and engagement. Educational efforts should include the creation of a mandatory environmental education curriculum in schools and universities across Colombia, ensuring long-term cultural change and awareness.

The process should also involve the strengthening of communication channels to reach all educational levels and sectors (public, private, productive, and social), providing practical tools for local implementation and increasing trust in biodiversity conservation efforts. Finally, it is important to foster dialogue spaces between scientists, technicians, and decision-makers, ensure continuous training, and organize follow-up workshops after information-sharing sessions to assess integration into institutional processes and identify gaps and opportunities for improvement.

The respondents favoured institutions and organizations, they would like to intensify communication include: The Humboldt Institute, IDEAM, WWF, Ministry of Health, Ministry of Transport, UNDP and in general terms scientific and research institutes. The formats included beside traditional written forms such as reports and official documents, more interactive and direct communication means. Specific formats mentioned among others were: workshops, conferences, expert advice and technical assistance, data-sharing, summaries for policymakers, successful case studies, communication through scientific institutions,

3.3 DR Congo

3.3.1 Information on Respondents

In DR Congo in total 38 respondents completed the survey. In DRC, the most common form of contribution is the provision of technical or professional expertise (16 respondents), followed by communication or internal forwarding of biodiversity-climate recommendations (8 respondents). Fewer respondents (5) reported being involved in decision-making roles that incorporate climate and biodiversity concerns. This suggests that many actors in the DRC network are positioned as knowledge providers or intermediaries rather than formal decision-makers. The relatively high level of technical contributions likely reflects the engagement of scientific, NGO, and international actors in supporting evidence-informed processes, rather than directly determining outcomes. For further actor specific distribution see the Appendix.

3.3.2 Network

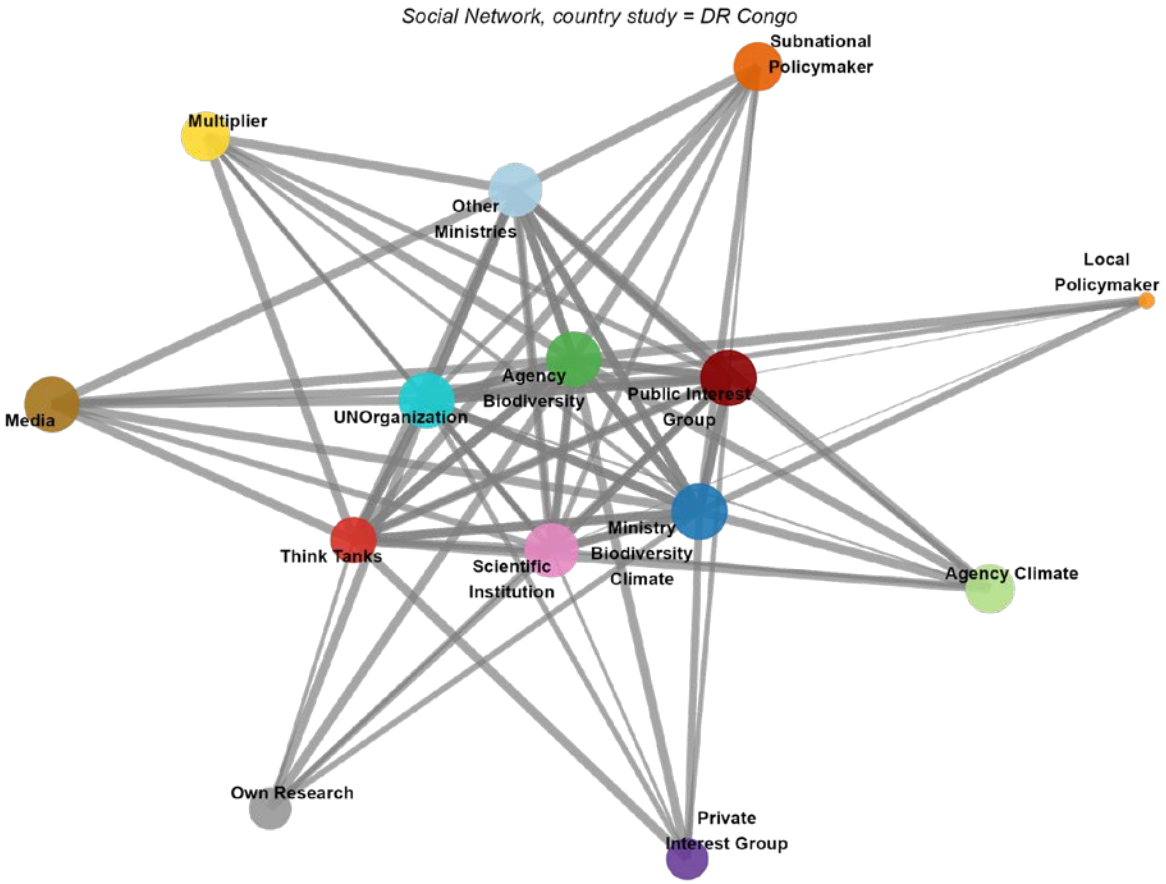

Figure DRC-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in DR Congo.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Table DRC-1.

Node	InDegree	OutgoingFlow	Betweenness
OtherMinistries	7	6.29	0
PublicInterestGroup	7	6.89	0.00794
ScientificInstitution	7	6.53	0.00794
UNOrganization	7	6.78	0.00794
AgencyBiodiversity	7	6.71	0
AgencyClimate	7	5.56	0
Media	7	6.71	0
MinistryBiodiversityClimate	7	6.89	0
Multiplier	7	5.53	0
SubnationalPolicymaker	7	5.59	0
ThinkTanks	6	5.18	0
OwnResearch	6	4.59	0
PrivateInterestGroup	6	4.57	0
LocalPolicymaker	5	2.95	0
Institut Congolais pour la Conservation de la Nature	0	0	0
MinistryBiodiversity	0	0	0

Table DRC-2.

Metric	Value
Number of Nodes	16
Number of Edges	93
Number of Isolates (in=0)	2
In-Degree Centralization	0.079

The SNA for DRC highlights a broad and balanced biodiversity–climate information landscape, with multiple actor types recognized equally as knowledge providers. Among the 16 actor categories included in the network, 14 were cited at least once as sources of information, while two, the Ministry of Biodiversity and the Institut Congolais pour la Conservation de la Nature (ICCN), were not mentioned by any respondents, and thus remain isolates. The network consists of 93 directed edges and an in-degree centralization score of 0.079, indicating a low concentration of information flow and suggesting that knowledge provision is spread across a wide array of actors. This structure points to a moderately decentralized system, where no single institution dominates the science-policy interface.

Ten actor types share the maximum in-degree value of 7, meaning each was identified as a source of information by all seven respondent actor groups. These include: Public Interest Groups; Scientific Institutions; UN Organizations; Media; Multiplier Organizations; Agency for Biodiversity; Agency for Climate; Ministry of Biodiversity and Climate; Other Ministries; Subnational Policymakers. This reflects a distributed landscape of knowledge providers that spans government agencies, civil society, international organizations, and scientific actors.

When considering total outgoing normalized flow, Public Interest Groups and the Ministry of Biodiversity and Climate stand out with the highest values (6.89), followed closely by UN Organizations (6.78), Media (6.71), and Agency for Biodiversity (6.71). These scores highlight actors that were not only frequently cited but also widely recognized across multiple respondent categories — suggesting consistent informational relevance rather than isolated mention.

Although betweenness centrality values are generally low, three actors show modest but measurable levels (0.00794): Public Interest Groups, Scientific Institutions, and UN Organizations. This suggests that these

groups may play limited but discernible roles in connecting otherwise disconnected parts of the network, potentially facilitating inter-sectoral knowledge transfer.

Private Interest Groups, Local Policymakers, and Think Tanks register moderate to low values in both in-degree and flow, indicating more peripheral roles in the current configuration of knowledge exchange. The two isolates — ICCN and the Ministry of Biodiversity — raise questions about institutional visibility or recognition. While both likely play substantial roles in biodiversity governance in practice, their absence from the reported information flows may reflect either a sampling gap or limited engagement with surveyed actor categories.

The DRC's biodiversity–climate knowledge network is marked by a pluralistic structure with multiple governmental and non-governmental providers operating in parallel. The presence of numerous actor types with equally high in-degree and flow scores suggests a multi-nodal, inclusive system of information provision. The moderate values of betweenness centrality imply that while information circulates broadly, cross-sectoral integration may still be limited. The exclusion of key institutions such as ICCN emphasizes the need to further explore recognition gaps and ensure that critical biodiversity actors are visible and engaged in the national science–policy interface. This insight may be useful for identifying stakeholders for interviews and national workshops under WP7, particularly where institutional presence does not yet translate into perceived relevance.

3.3.3 Information Flows

3.3.3.1 Information Flow by Format

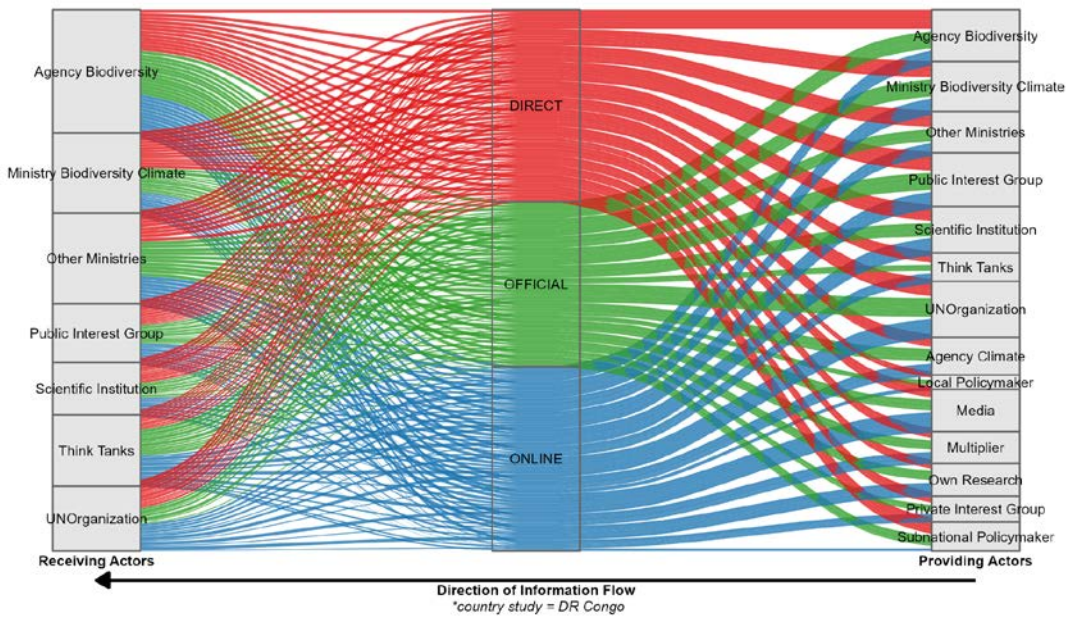

Figure DRC-2. Format-specific Sankey diagram showing how information from providers reaches receivers in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

The Sankey diagram displays the flow of biodiversity- and climate-related information across different provider and receiver groups in the DRC, disaggregated by communication format: Direct, Official, and Online.

Direct formats (red) are especially prominent among public authorities, notably between the Agency for Biodiversity, the Ministry for Biodiversity and Climate, and Other Ministries. This suggests strong intra-governmental interaction through personal meetings, workshops, and bilateral exchanges. Official formats (green), such as formal reports or legal/policy documents, are broadly distributed across all receiver types but are especially significant in exchanges involving ministries, agencies, and scientific institutions. This

pattern points to bureaucratic or procedural information channels that maintain legitimacy and institutional traceability. Online formats (blue) dominate the lower half of the diagram and are the most widely used overall. They are heavily employed by providers such as Scientific Institutions, Multipliers, and UN Organizations. Online information reaches nearly all actor categories but is particularly directed toward UN bodies, Scientific Institutions, and Public Interest Groups, suggesting digital platforms serve as a primary channel for transnational or evidence-based knowledge dissemination.

Multipliers and Scientific Institutions are both active users of all three formats, with a notable emphasis on online dissemination to a diverse set of actors, indicating their bridging role. Private and Public Interest Groups are visible in all formats as both providers and receivers, though the intensity of their outbound flows is lower compared to public sector bodies. UN Organizations primarily use online and official formats, consistent with their global knowledge dissemination function. They interact most frequently with public authorities and scientific institutions.

3.3.3.2 Receiver-Specific Information Flow

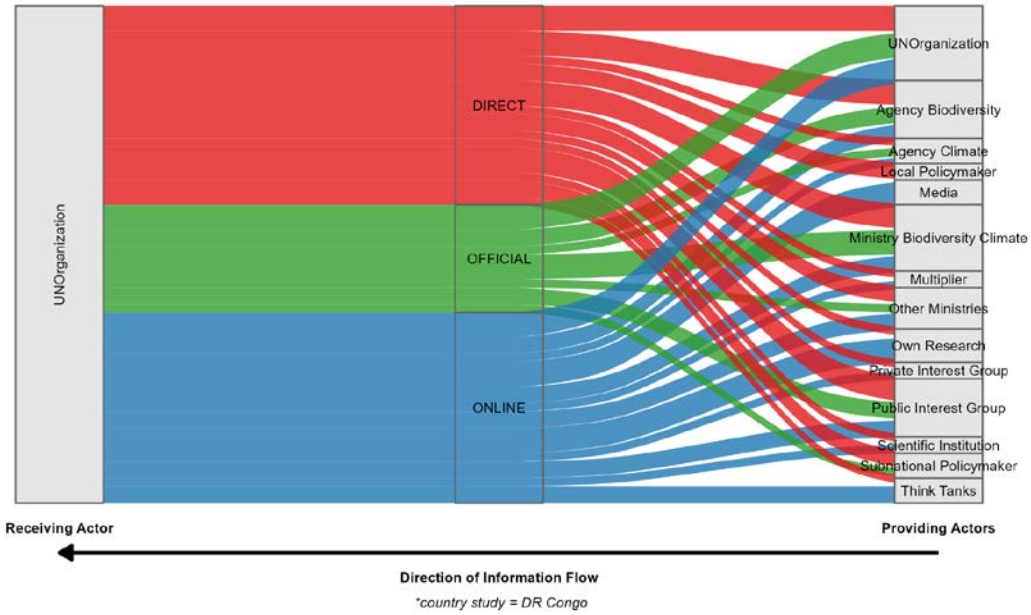

Figure DRC-3. Receiver-Specific (UN Organizations) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

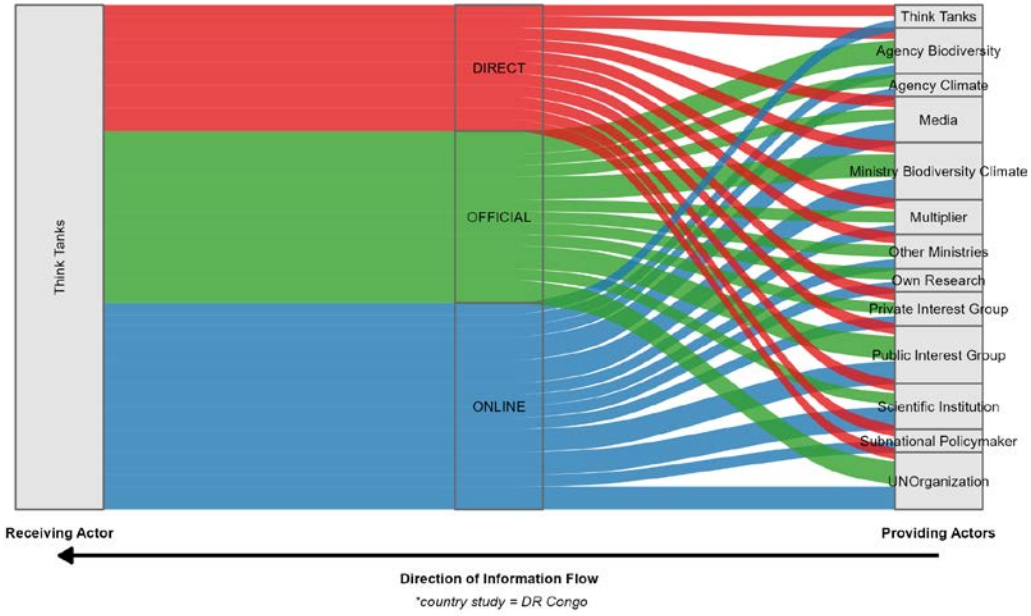

Figure DRC-4. Receiver-Specific (Think Tanks) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

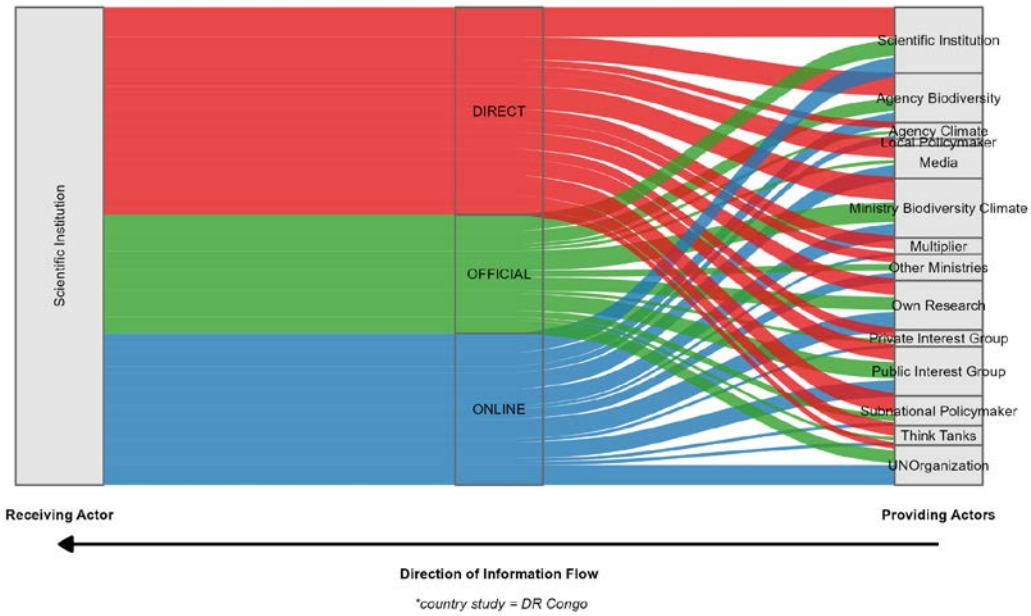

Figure DRC-5. Receiver-Specific (Scientific Institution) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

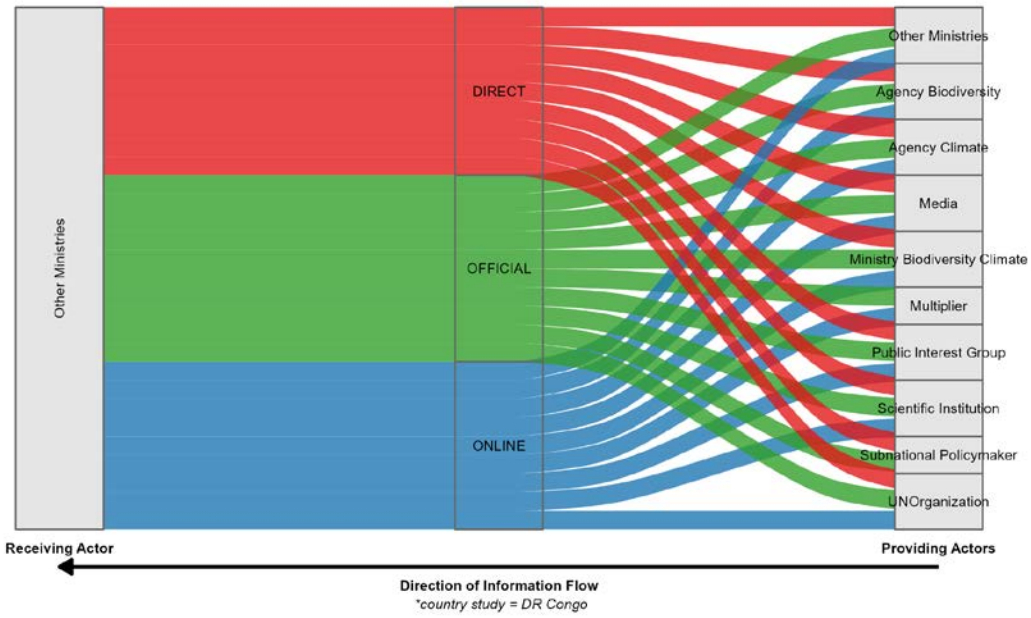

Figure DRC-6. Receiver-Specific (Other Ministries) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

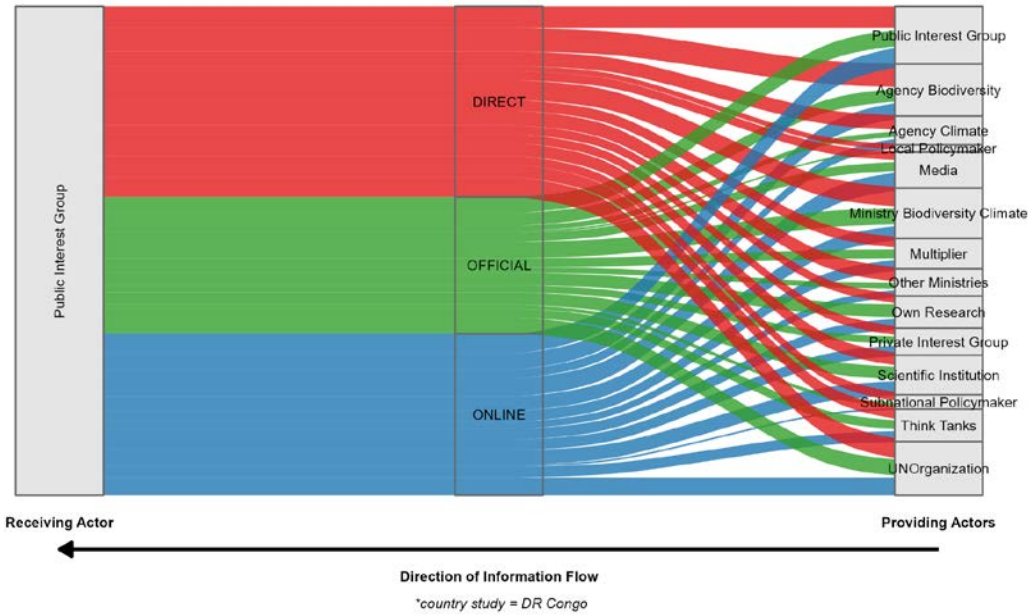

Figure DRC-7. Receiver-Specific (Public Interest Group) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

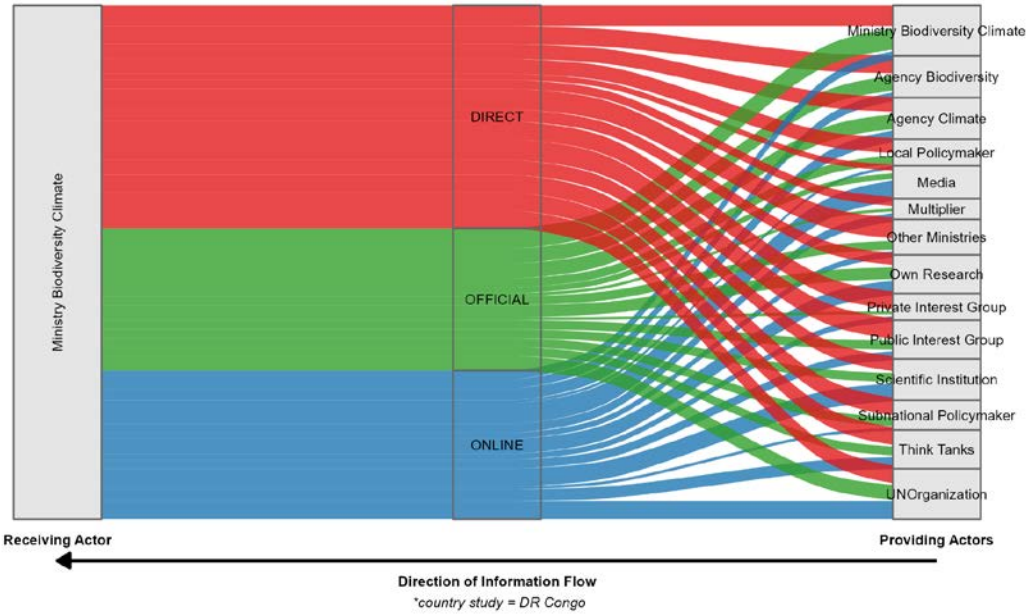

Figure DRC-8. Receiver-Specific (Ministry responsible for Biodiversity and Climate) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

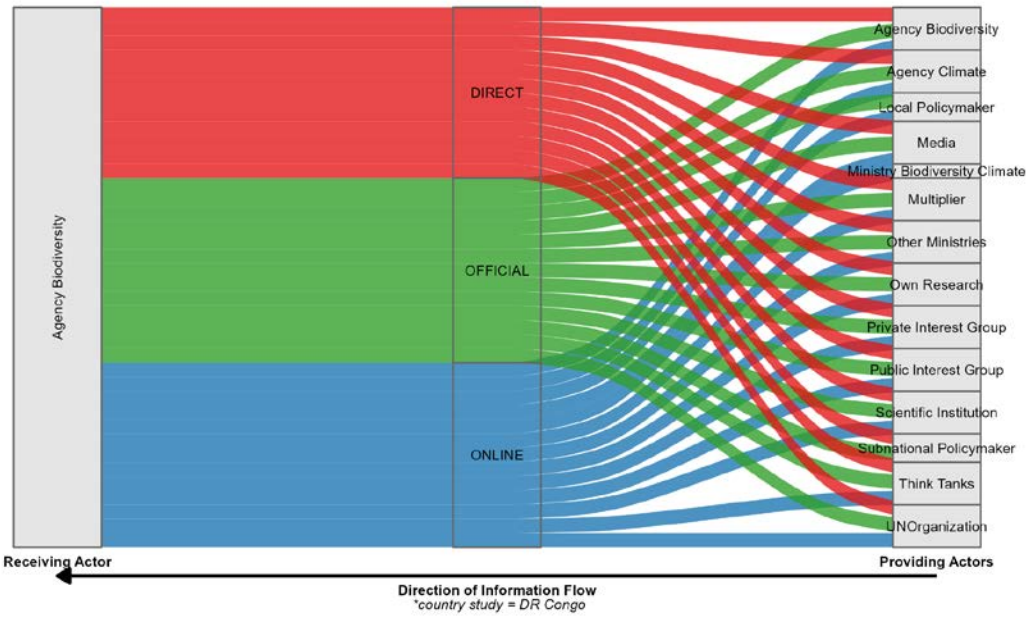

Figure 29. Receiver-Specific (Agency responsible for Biodiversity) Information Flow in DR Congo, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities

Ministry of Biodiversity and Climate: The Ministry emerges as a key national-level information provider, distributing knowledge relatively evenly across direct, official, and online formats. Most information is directed toward scientific institutions, other ministries, and public interest groups, with moderate outreach to private sector actors. There is some but limited engagement with UN organizations. The diversified communication strategy suggests institutional authority and effort to reach varied stakeholders, but the relatively low engagement with international actors or think tanks may limit the uptake of global knowledge or independent evaluation.

Agency Biodiversity & Agency Climate: Both agencies show substantial use of direct and official formats, less so online. Their primary information recipients are ministries, other agencies, and occasionally scientific institutions. Agencies also reach interest groups, albeit to a lesser extent. These agencies are embedded in bureaucratic knowledge exchange, largely targeting horizontal (intra-governmental) flows. The underuse of online tools could limit broader dissemination or transparency.

Subnational and Local Policymakers: Subnational actors favour direct communication, particularly targeting ministries, scientific institutions, and UN bodies. Local policymakers have more limited reach, with slightly narrower diversity of recipients, focused mostly on national political authorities and international organizations. While these actors do act as information sources, their scope and methods suggest a more vertical flow of information to national-level institutions, possibly reflecting reporting obligations rather than proactive knowledge-sharing. Their peripheral role may indicate underutilized local knowledge.

II. Scientific and Research Actors

Scientific Institutions: These institutions rely heavily on online dissemination, followed by official formats, and to a lesser extent, direct communication. They provide information broadly across all actor types, especially to ministries, other scientific institutions, and interest groups. Their outward flow profile indicates an emphasis on formal and accessible communication, typical of academic outputs. However, limited use of direct contact may hinder relational trust and actionable uptake.

Multipliers (e.g., training centres): Multipliers are prominent providers of online and official information, especially to ministries, scientific institutions, and civil society organizations. Their role as boundary actors is visible here, bridging institutional and community needs. However, limited direct contact with the private sector or international bodies may weaken their integration into global capacity-building efforts.

Media do not appear prominently in the dataset as providers in the DRC case. This likely reflects a structural disconnect between policy and public communication channels, possibly contributing to weak transparency or outreach.

III. Interest and Advocacy Groups

Public Interest Groups: These actors show balanced use of all three formats. Their information is directed broadly, with notable flows to ministries, scientific institutions, and UN organizations. This reflects a strategic, multi-scalar communication profile. The diversity of targets and balanced formats underscores their role as active policy interlocutors.

Private Interest Groups: Private actors are underrepresented as providers. Where present, they favour official and online formats and mostly target ministries and scientific institutions. The limited scale suggests a passive role in policy communication, possibly due to proprietary or competitive concerns. Their marginal position in the network may hinder integration into national knowledge systems.

IV. Think Tanks and Capacity Building Organisations

Think Tanks: These are very marginal actors in the DRC case. Where present, they use a mix of official and online formats and target ministries and scientific institutions. Their absence limits independent analytical input and constraints critical policy reflection. Their development could strengthen cross-sectoral dialogue.

UN Organizations are visible as important providers of information, with online formats dominating, followed by official and then direct exchanges. Recipients include Ministries, Agencies, Public Interest Groups, and Scientific Institutions. Self-referencing links also indicate interaction between UN bodies. These patterns align with the UN's global knowledge dissemination model — largely unidirectional and standardized, which may limit context responsiveness.

Cross-Cutting Observations for DRC:

- High reliance on direct formats: Many provider types (e.g., Public Interest Groups, Think Tanks, Private Sector) rely heavily on direct communication, suggesting a strong preference for personalized or informal exchange over bureaucratic channels.

- Government authorities as central recipients: Across all providers, the Ministry and Agency for Biodiversity/Climate are consistently the most targeted recipients, showing their centrality in the national knowledge system.

- Scientific institutions as secondary recipients: These are regularly engaged by multiple provider types, but rarely through direct formats, perhaps reflecting their consultative or analytical roles rather than political decision-making ones.

- Limited cross-sectoral engagement by local policymakers: Local and subnational policymakers in DRC provide information to a narrower group of actors, mostly upward to ministries or UN bodies, with less lateral exchange across sectors.

Potential Gaps: Despite the range of actors involved, Think Tanks and Multiplier institutions appear to receive or provide less information comparatively, a possible gap in intermediary-led knowledge mobilization.

3.3.3.3 Links between Organizations

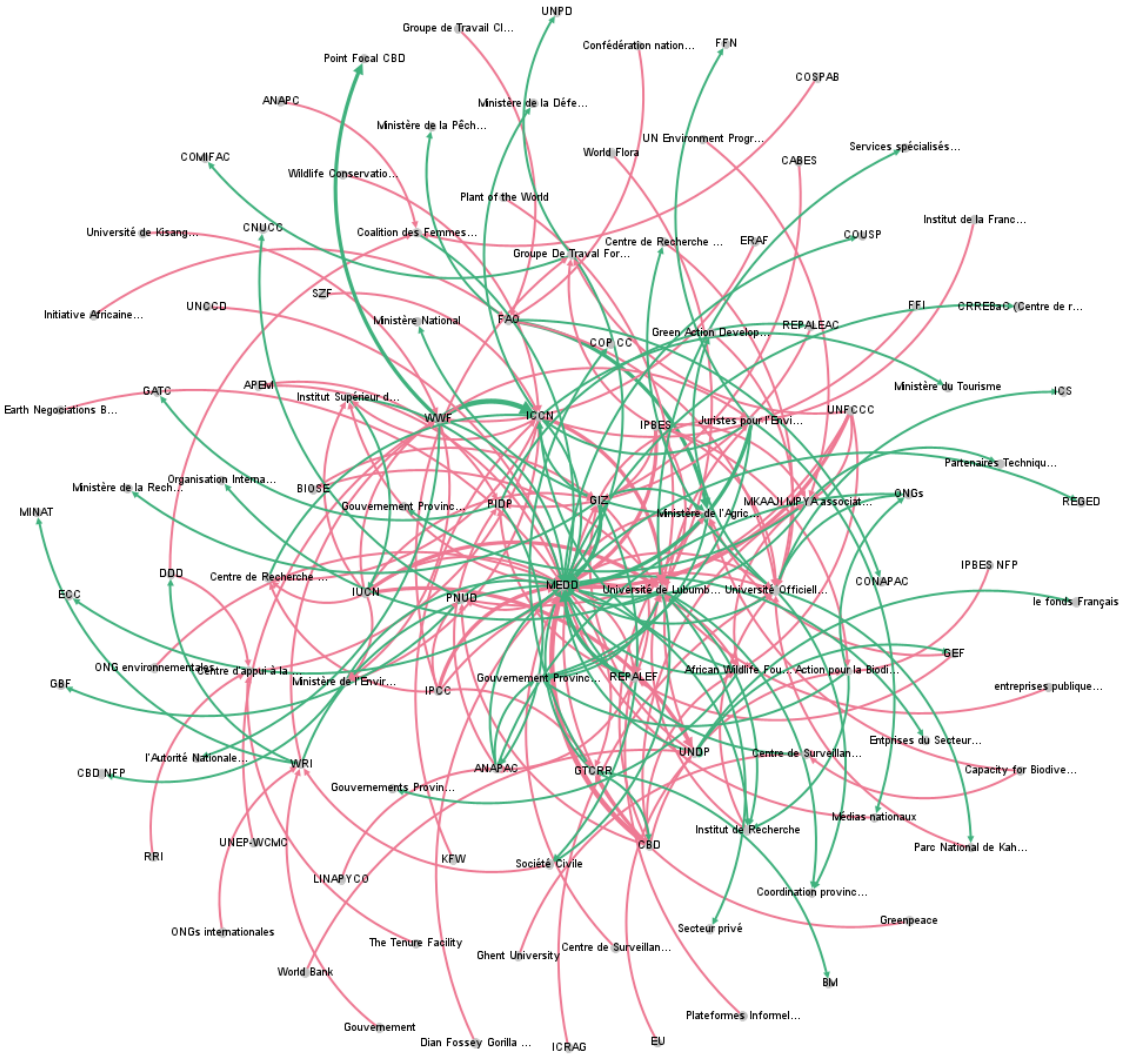

Figure DRC-9: *Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.*

This figure illustrates the directed information flows between surveyed organizations within the biodiversity–climate knowledge system in the Democratic Republic of the Congo (DRC). The map is based on respondent-reported ties indicating which organizations they send information to and receive information from. Arrows represent the direction of knowledge exchange; edge thickness corresponds to normalized frequency. The figure reflects how knowledge moves across national, subnational, and international actors within DRC's science-policy interface.

The network is characterized by a highly centralized and vertically oriented structure, with the Ministère de l'Environnement et Développement Durable (MEDD) occupying the most dominant position. MEDD receives and distributes information across a wide range of actors, including technical bodies, donors, and civil society, confirming its central role as both a policy coordinator and a conduit for incoming knowledge.

Its prominent bidirectional ties suggest both influence and reliance, positioning it as a linchpin in the national system.

Two technical institutions, ICCN (Institut Congolais pour la Conservation de la Nature) and Institut de Recherche, appear as active providers, connected to both government actors and international organizations. While their roles are not as central as MEDD, they serve as important sources of environmental or biodiversity-related expertise. Their inclusion suggests some degree of internal technical capability, though their lower visibility implies limited brokerage power.

Several international organizations and science platforms, including IPBES, CBD, IPCC, and IUCN, appear exclusively as providers, with multiple outward-facing edges and no incoming ties. This reflects their normative authority and strong influence on DRC's policy landscape. However, the absence of feedback loops indicates minimal two-way exchange, reinforcing a unidirectional model of scientific influence from global to national levels. A set of donor-linked and multilateral organizations, such as GEF, UNDP, and the World Bank, occupy intermediary positions in the network. Their connections to both international and national actors suggest a project-based flow of knowledge, where funding structures and implementation partnerships shape who shares and receives information.

Peripheral actors in the system include a range of civil society organizations, NGOs, provincial governments, and private sector entities. These nodes are primarily on the receiving end of information flows, with little evidence of them serving as active providers or intermediaries. This pattern indicates an aspirational inclusion logic, where many actors are named as important for outreach or coordination but remain structurally marginal.

Notably, research institutions and universities are largely absent or appear only at the edges of the network. The lack of central academic actors points to a limited integration of domestic scientific institutions into the national knowledge system. This reinforces a model in which policy is informed primarily through external knowledge inputs and centralized administrative decision-making, rather than through iterative or peer-based exchange.

Overall, the DRC network displays a state-centric, externally influenced configuration, where vertical flows from global organizations to the central ministry dominate. While some national technical bodies serve contributory roles, the broader structure suggests limited horizontal knowledge exchange, low territorial decentralization, and underutilization of academic and civil society expertise. This has implications for adaptive capacity and long-term institutional learning in the country's biodiversity and climate governance architecture. The fact that so many organizations are listed as recipients of forwarded information, but not as sources, suggests aspirational connections rather than established exchange relationships[3].

[3] As with all other country cases, the DRC sample emphasized public agencies, NGOs, and selected scientific actors. While the sample includes a relatively rich mix of institutions, it is likely that media, subnational officials, and academic actors are underrepresented. As such, the chord diagram reflects perceived, not exhaustive, information flows.

3.3.4 Facilitation and Improvement of Knowledge Exchange

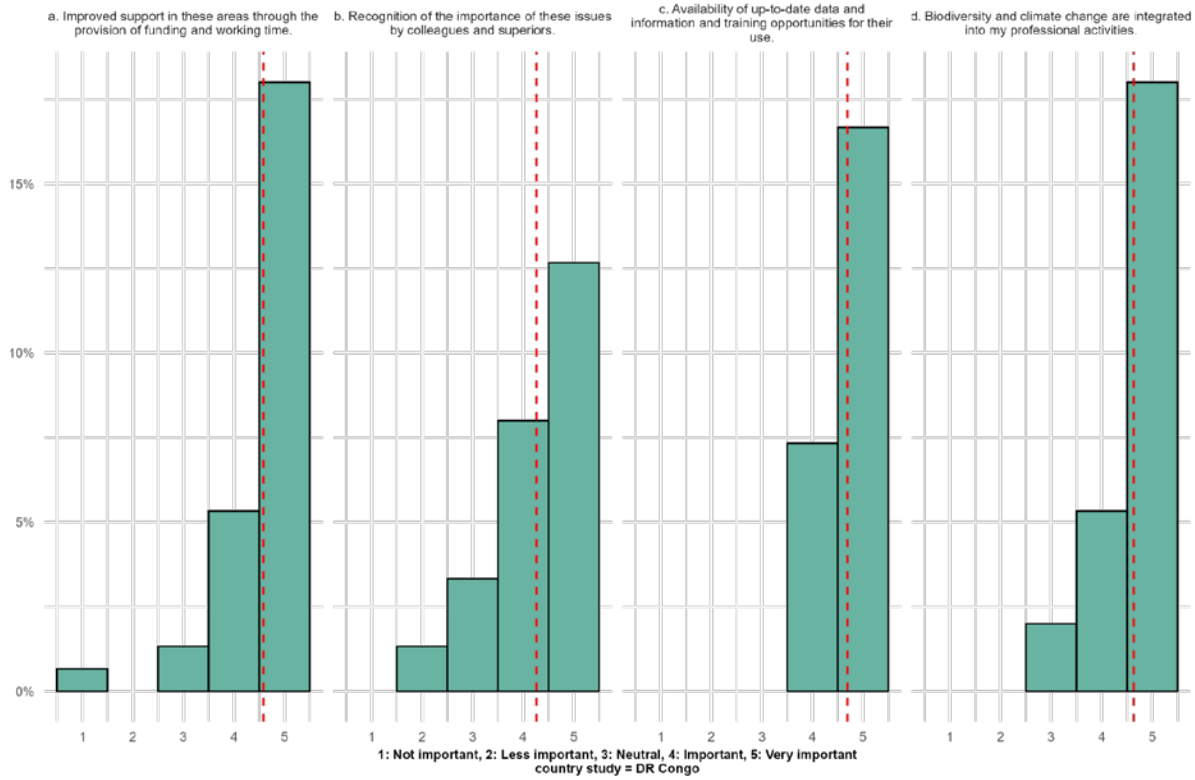

Figure DRC-10. Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

This figure captures respondent agreement with four statements related to institutional and professional conditions supporting biodiversity–climate knowledge exchange. The results show very high levels of agreement across all four dimensions, with means ranging from 4.26 to 4.69, indicating a broadly supportive and enabling environment.

The highest average agreement is found for the statement that respondents *have access to up-to-date information and training opportunities* (mean 4.69). This suggests that respondents feel confident in the availability of timely, relevant knowledge and learning resources, which is essential for effective engagement with biodiversity–climate topics. Closely following is the statement that *biodiversity and climate change are integrated into respondents' professional activities*, with a mean of 4.63. This points to a strong alignment between environmental themes and respondents' core responsibilities, indicating high levels of institutional mainstreaming of these issues within their professional contexts.

Support in the form of *funding and time allocation* also scores highly (mean 4.58), suggesting that organizations provide not only conceptual but also material support for knowledge exchange activities. This is critical in resource-constrained contexts like DRC, where institutional capacity is often a limiting factor. The lowest, yet still favourable, agreement is found for the statement that *colleagues and supervisors recognize the importance of biodiversity–climate issues* (mean 4.26). While still strong, this comparatively lower score may reflect some internal inconsistencies in organizational culture, potentially indicating a gap between formal mandates and interpersonal or managerial reinforcement.

Overall, the data portray an encouraging picture of the institutional and professional climate for knowledge exchange in DRC. Respondents perceive strong integration of biodiversity and climate themes into their work, adequate support for engaging with these topics, and solid access to data and training. The slightly lower score on interpersonal recognition underscores the importance of not only institutional structures

but also peer support and leadership engagement in fostering long-term knowledge exchange cultures. These findings are particularly notable given the governance and capacity challenges often associated with the DRC context; they suggest a relatively resilient and motivated community of practice, likely tied to specific national or international initiatives focused on capacity-building.

Preferred formats of information exchange

Stakeholders expressed interest in intensifying collaboration with actors across government, civil society, research institutions, the private sector, and international organizations. At the national and subnational levels, specific institutions mentioned include the Ministry of Environment and Sustainable Development (MEDD), Parliament, the Fonds Forestier National, ICCN, the Plateforme BioSE-RDC (Biodiversity and Ecosystem Services Platform), and provincial environmental coordinations. Civil society platforms such as CONAPAC and ANAPAC, as well as scientific and academic institutions, were also named.

Internationally, respondents identified key development and environmental partners - including FAO, UNEP, UNDP, the World Bank, USAID, the European Union, the German Development Bank, GIZ, and the Agence internationale de la Francophonie - as potential collaborators. Environmental NGOs (e.g., WWF, WCS, African Wildlife Foundation) and science-policy platforms such as the IPCC, IPBES, UNFCCC, IUCN, and GEF were also seen as critical partners.

Preferred formats for engagement included both formal and informal mechanisms: workshops, seminars, expert consultations, conferences, official reports, emails, and digital or print media. Joint initiatives were also highlighted as an important avenue for sustained collaboration.

Respondents emphasized the need for coordinated efforts across four main areas:

Institutional Strengthening and Coordination: Enhance the capacity and operational effectiveness of national and local institutions, ensuring adequate human, technical, financial, and infrastructural support. Respondents called for biodiversity and climate to be treated as cross-cutting priorities and better mainstreamed into governance.

Capacity Building and Inclusive Participation: Strengthen the skills of decision-makers, researchers, and civil society through targeted training and environmental education. Respondents also advocated for more inclusive participation of scientists, local communities, indigenous knowledge holders, and private sector actors in policy processes.

Communication and Outreach: Develop national communication strategies and leverage a diversity of dissemination channels, including community radio, social media, religious institutions, and universities, to broaden access to information and engage multiple stakeholder groups.

Improved Access and Evidence Mobilization: Increase access to decision-relevant scientific information through summaries, digital tools, and open databases. Establish coordination platforms to enable cross-sectoral and multi-level knowledge exchange, and support localized research initiatives to ground policies in context-specific evidence.

Together, these insights highlight the need for both horizontal and vertical integration of knowledge systems to ensure more informed, inclusive, and actionable climate and biodiversity policymaking in the DRC.

3.4 Finland

3.4.1 Information on Respondents

In Finland, a total 37 of respondents completed the survey. Among Finnish respondents, the most frequently reported role is the provision of technical or professional expertise (just under 30 respondents), highlighting a strong emphasis on analytical input or evidence-based support in national biodiversity–climate work. This is followed by internal communication or forwarding of recommendations (approximately 24), suggesting a secondary but substantial function of organizational knowledge brokerage. In contrast, fewer respondents report making formal decisions (about 9), indicating that while technical and communicative roles are well represented, decision-making authority is less prominent within the sampled actors. This pattern suggests a respondent base skewed toward advisory and intermediary functions over policy leadership. For further actor specific distribution see the Appendix.

3.4.2 Network

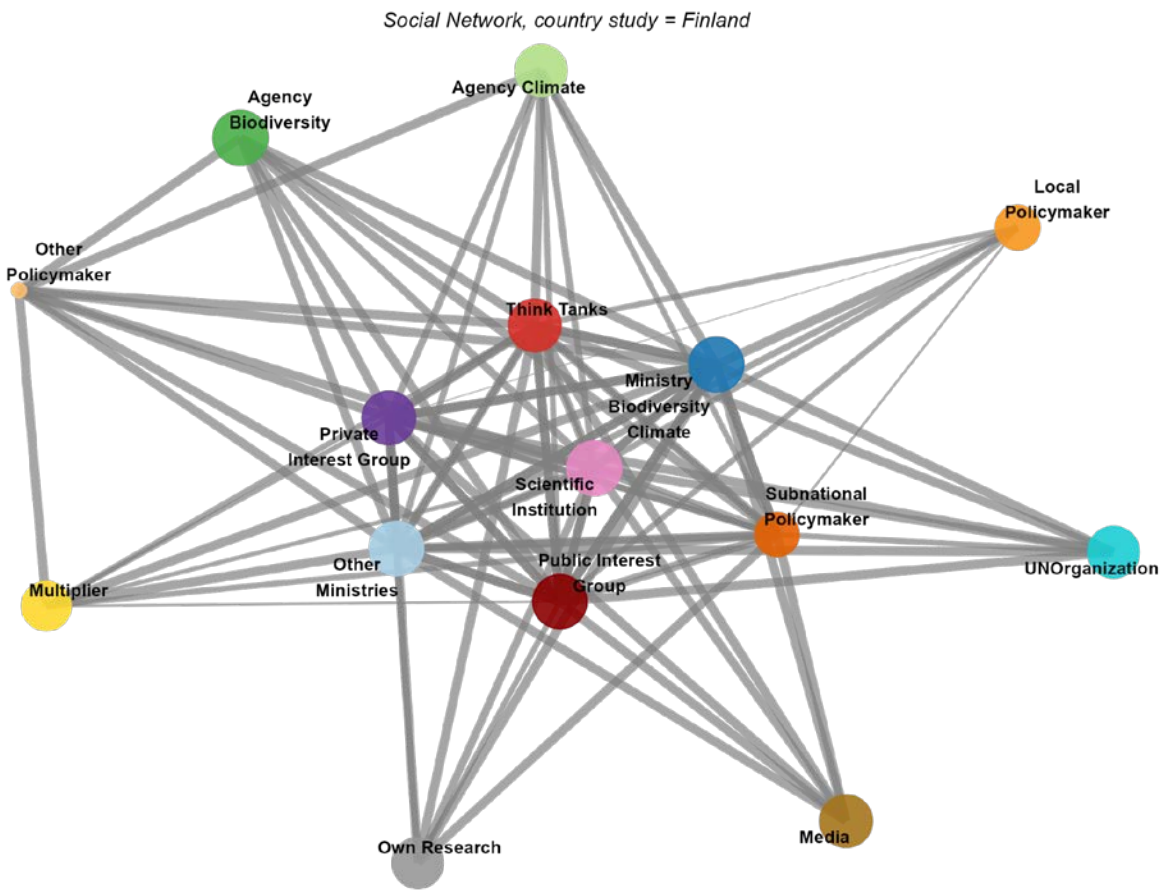

Figure FIN-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Finland.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	InDegree	OutgoingFlow	Betweenness
MinistryBiodiversityClimate	8	7.88	0.00458
OtherMinistries	8	7.71	0.00458

PrivateInterestGroup	8	7.37	0.00458
PublicInterestGroup	8	7.61	0.00458
ScientificInstitution	8	7.88	0.00458
ThinkTanks	8	7.08	0.00458
AgencyBiodiversity	8	7.88	0
AgencyClimate	8	6.65	0
Multiplier	8	5.80	0
SubnationalPolicymaker	7	4.18	0
LocalPolicymaker	7	4.32	0
Media	7	6.94	0
OwnResearch	7	6.30	0
UNOrganization	7	6.61	0
OtherPolicymaker	0	0.00	0

Table FIN-1.

Metric	Value
Number of Nodes	15
Number of Edges	107
Number of Isolates (in=0)	1
In-Degree Centralization	0.062

Table FIN-2.

The Social Network Analysis (SNA) of Finland reveals a highly integrated and egalitarian structure of biodiversity–climate knowledge exchange. The network comprises 15 actor types and 107 directed information ties. With only one isolate ("OtherPolicymaker") and an in-degree centralization score of 0.062, the network is notably decentralized and inclusive, with no actor type monopolizing the flow of information.

Ten actor categories exhibit the maximum in-degree score of 8, indicating that every respondent group reported receiving information from these providers. This group includes a diverse mix of public authorities, civil society organizations, scientific bodies, and intermediaries, illustrating a well-established knowledge ecosystem in which multiple institutions are broadly recognized as legitimate and visible sources of information.

Normalized outgoing flow values help further differentiate actors with similar in-degree scores. The Ministry of Biodiversity and Climate, Scientific Institutions, and Agency for Biodiversity all record the highest normalized flow (7.88), suggesting that they are not only frequently cited, but also consistently referenced across multiple respondent types. Together, they form the structural core of the Finnish network in terms of perceived information provision. Public and Private Interest Groups, Think Tanks, and Other Ministries also show high flow scores (all above 7.0), confirming their active role in disseminating information.

Six actors, including Scientific Institutions, the Ministry of Biodiversity and Climate, Public and Private Interest Groups, Think Tanks, and Other Ministries, display non-zero betweenness centrality (0.00458), the highest value recorded in this network. While modest, these values indicate that they may serve as weak intermediaries or points of intersection between otherwise separate flows of information. The uniformity and low overall magnitude of betweenness suggest that brokerage is not a dominant structural feature of the network, but is shared across a set of similarly positioned actors.

More peripheral actors include Subnational and Local Policymakers, the Media, and Own Research. Although their in-degree values remain high (7), they show comparatively lower outgoing flow scores (ranging from 4.18 to 6.94), suggesting that while they are commonly identified as recipients of information,

they may play more specialized or passive roles in national-level provision. The single isolate, "OtherPolicymaker," was not cited as a provider by any respondents and likely reflects either low visibility or lack of clear institutional recognition in the survey responses.

Overall, Finland's network exhibits a distributed, non-hierarchical configuration, with a broad set of actors participating in the exchange of biodiversity–climate knowledge. Governmental bodies and scientific institutions jointly anchor this network, supported by civil society and private sector actors that are similarly active in provision. This redundancy in the system may enhance resilience, accessibility, and mutual accountability across the science–policy interface. However, the absence of strongly differentiated brokerage roles suggests that future coordination efforts may benefit from targeted mechanisms to improve cross-sectoral integration, especially between localized actors and national-level hubs. As in other countries, the sampling strategy emphasized formal policy institutions, research organizations, and intermediary actors. Therefore, the absence of certain universities or mass media outlets should not be interpreted as disengagement but rather as a reflection of survey design.

3.4.3 Information Flows

3.4.3.1 Information Flow by Format

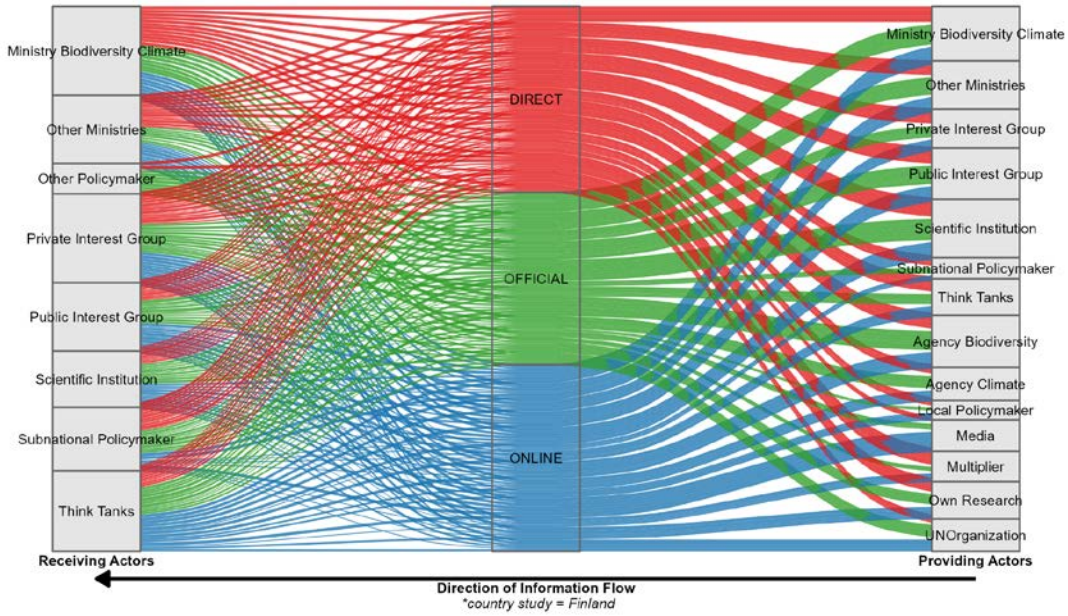

Figure FIN-*2. Format-specific Sankey diagram showing how information from providers reaches receivers in Finland, segmented into three formats: Digital and online media (websites, social media, newsletters); Official and formal documents (reports, summary for decision-makers, IPCC reports, IPBES reports, information sheets) and Direct and indirect communication (emails, phone calls, expert advice, workshops, conferences)*

Dominant formats: Online is the most widely used format across all providers. A substantial portion of information flows from nearly every actor, including Ministries, Agencies, Scientific Institutions, Media, and UN organizations, occurs online. Official formats are the second most used, especially for communication from public authorities (e.g., Ministries, Agencies) and Scientific Institutions. Direct communication is relatively less frequent overall, but still visibly present, particularly from Ministries, Think Tanks, and Civil Society groups.

Major providers include Scientific Institutions, Ministries, Agencies, Think Tanks, and UN Organizations. Each shows high volumes of outgoing information, often channelled through online or official means. Main recipients are the Ministry of Biodiversity/Climate, Other Ministries, Scientific Institutions, and

Public Interest Groups. Subnational Policymakers, Think Tanks, and Private Interest Groups also receive substantial flows, but somewhat less prominently.

Scientific Institutions and Ministries receive a high proportion of official and online format flows. Public Interest Groups and Private Interest Groups are more frequently targeted via online formats, although some direct communication exists. Subnational Policymakers are reached largely through online and direct formats, hinting at decentralized interactions.

The Finnish system displays a relatively balanced use of all three formats, online, official, and direct, but leans strongly toward online exchanges, reinforcing Finland's reputation for digital-forward public communication and openness in government science-policy processes. The notable presence of official formats, particularly among Ministries, Agencies, and Scientific Institutions, suggests that information exchange is partly embedded in bureaucratic and regulatory mechanisms, facilitating traceability and formality. The volume and diversity of flows between Scientific Institutions and Public Authorities (ministries and agencies) underscore a relatively dense and reciprocal science–policy interface. This aligns with Finland's strong emphasis on evidence-based policy and coordinated inter-agency knowledge platforms.

Subnational Policymakers and Private Interest Groups receive fewer flows, which may point to gaps in vertical integration and sectoral engagement. Think Tanks and Public Interest Groups appear as both providers and recipients, but their involvement skews toward informal and online methods, suggesting possible marginalization from formal decision structures.

3.4.3.3 Receiver-Specific Information Flow

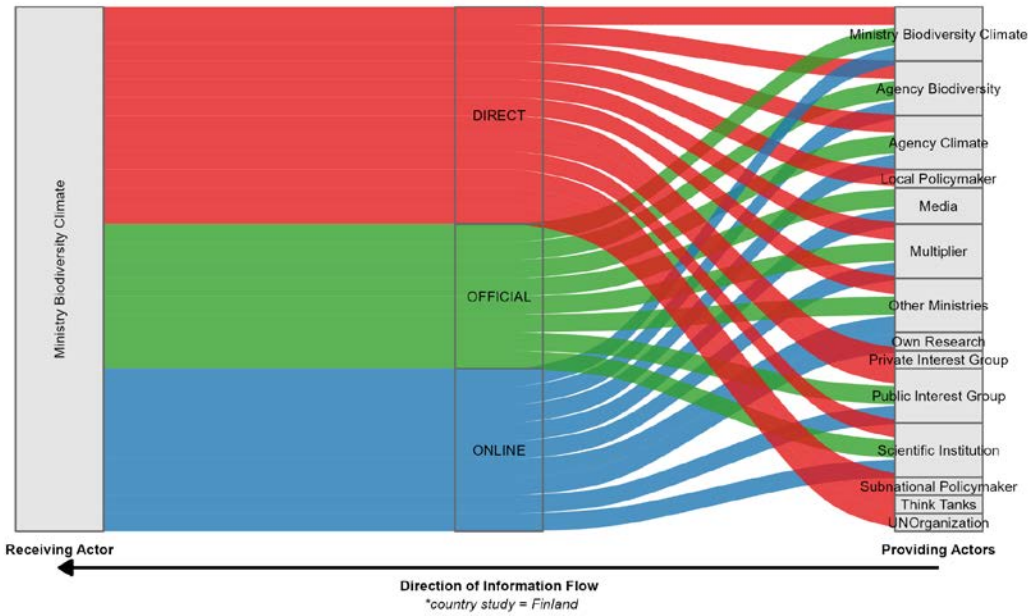

Figure FIN-3. Receiver-Specific (Ministry responsible for Biodiversity and Climate) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

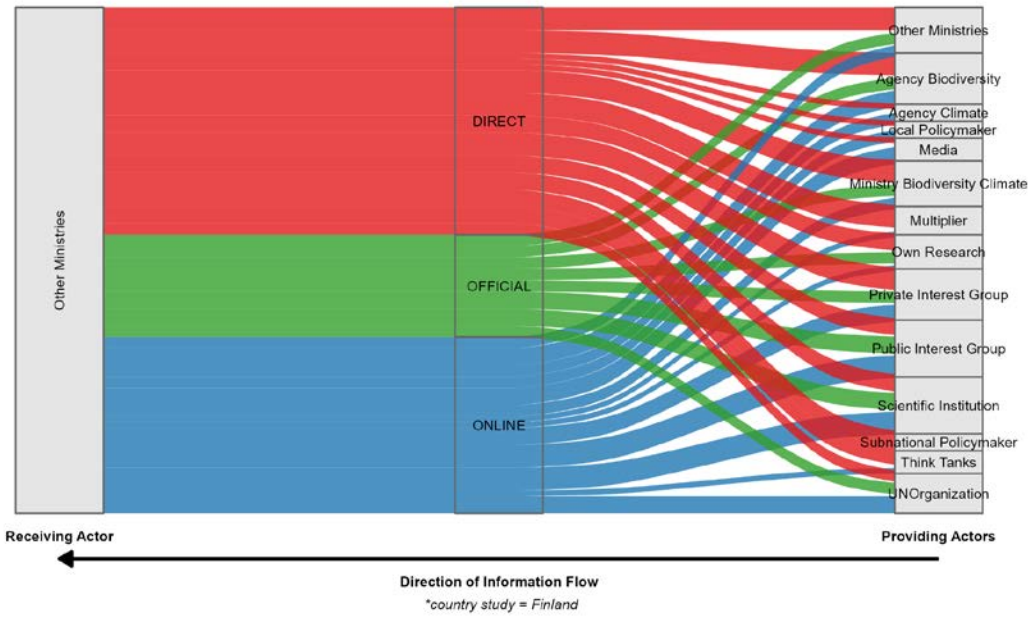

Figure FIN-4. Receiver-Specific (Other Ministries) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

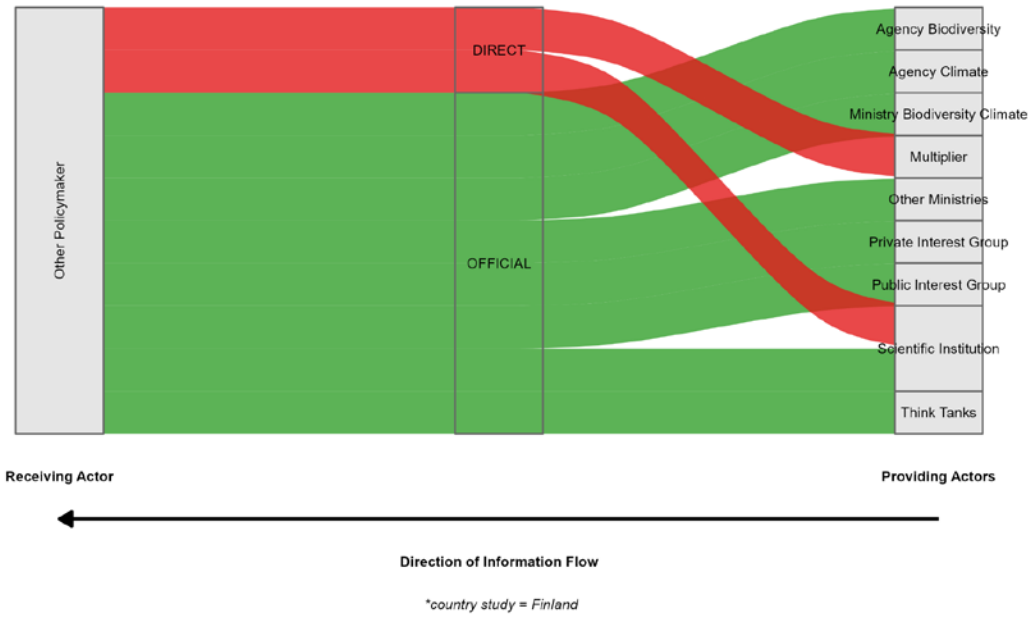

Figure FIN-5. Receiver-Specific (Other Policymakers) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

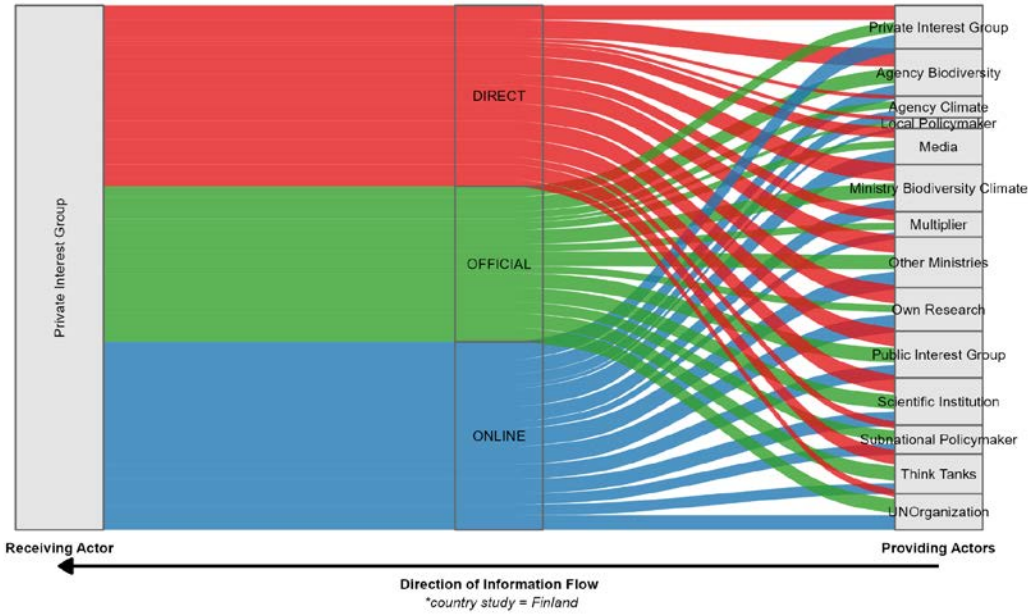

Figure FIN-6. Receiver-Specific (Private Interest Group) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

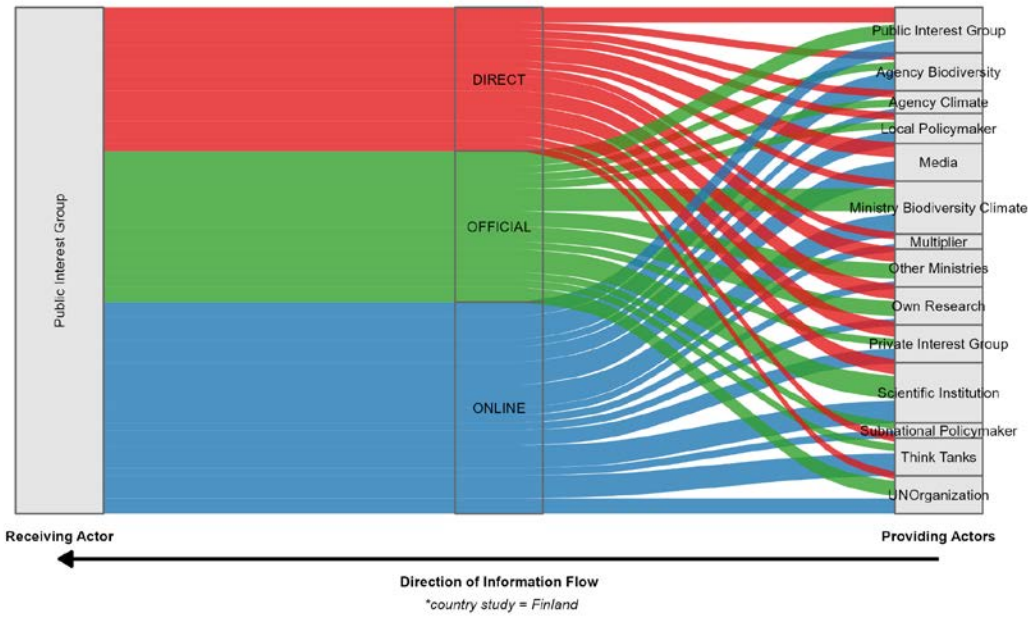

Figure FIN-7. Receiver-Specific (Public Interest Group) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

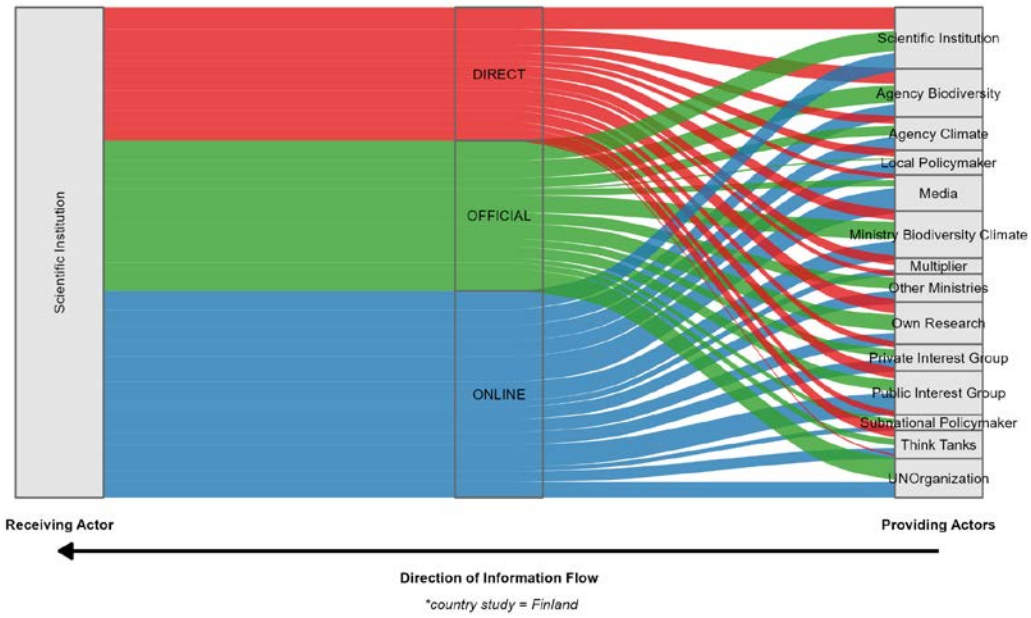

Figure FIN-8. Receiver-Specific (Scientific Institution) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

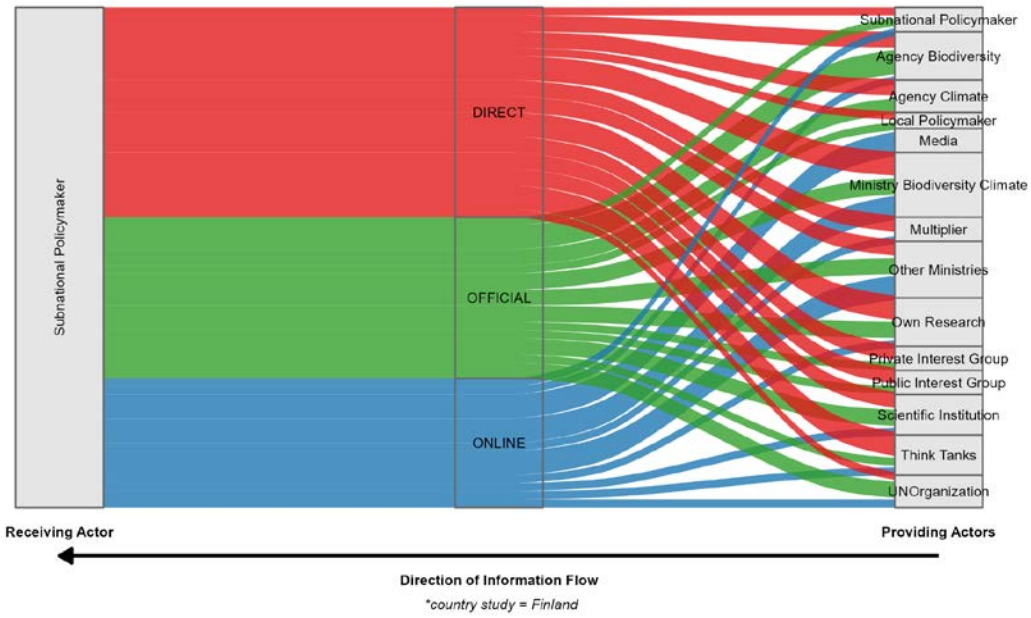

Figure FIN-9. Receiver-Specific (Subnational Policymaker) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

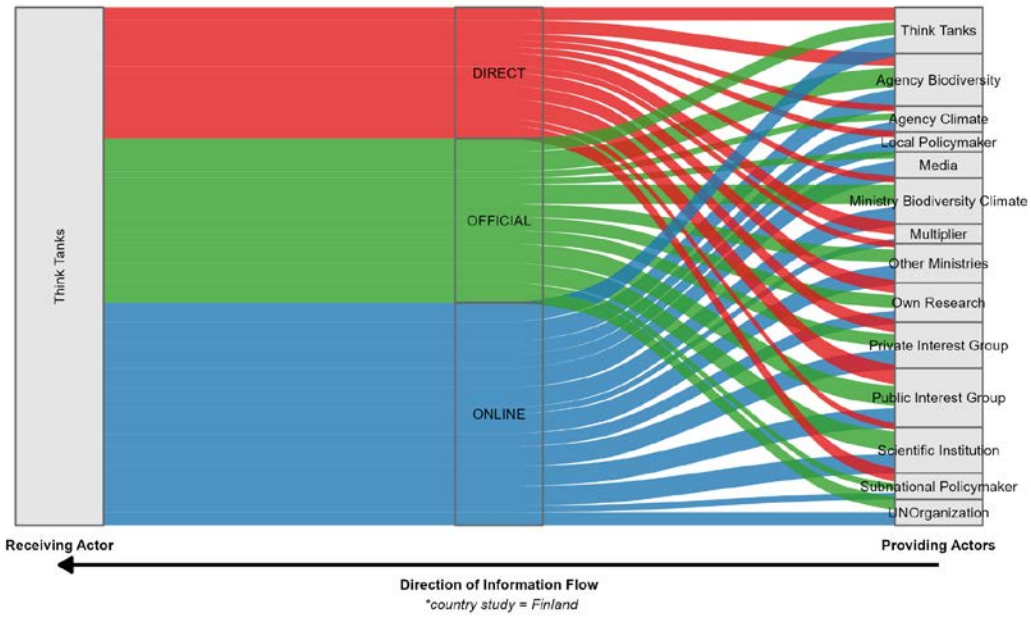

Figure FIN-10. Receiver-Specific (Think Tanks) Information Flow in Finland, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities

The analysis of provider-specific Sankey diagrams for Finland reveals a robust and differentiated pattern of information dissemination among public authorities, with notable variation in preferred formats and target audiences. Across ministries, agencies, and subnational/local policymakers, all three formats—direct exchange, official channels, and online dissemination—are employed, though the proportional emphasis and relational reach vary across institutional levels.

The Ministry of Biodiversity and Climate distributes information using all three formats in near-equal proportions, with a slight predominance of official communication. It serves as a central provider to a broad array of actors, including other ministries, public and private interest groups, and scientific institutions. The reach to subnational actors and think tanks, though present, is somewhat more limited in volume, reflecting a pattern of outreach that is both hierarchical and horizontal across sectors.

The Agency for Climate adopts a similarly balanced communication approach, with a minor skew toward official and online formats. The agency primarily shares information with other ministries, private sector organizations, scientific institutions, and subnational policymakers. Although it also communicates with public interest groups and think tanks, these flows appear less frequent, potentially indicating a focus on administrative coordination and technical engagement over advocacy interfaces.

The Agency for Biodiversity likewise demonstrates high-format diversity, with direct, official, and online exchanges occurring in roughly equal measure. The agency maintains strong ties with ministries, private interest groups, civil society organizations, and scientific institutions. Notably, its interactions with subnational policymakers and think tanks suggest a relatively inclusive communication strategy that supports both vertical coordination and horizontal exchange.

Subnational policymakers, in contrast, show a strong preference for direct exchange, followed by official and then online formats. Their information provision is mainly oriented toward other political institutions, including ministries and agencies, but also extends to private and public interest groups, scientific institutions, and to a lesser extent, think tanks. This format preference implies reliance on established

networks and interpersonal relationships rather than formalized bureaucratic channels, possibly due to capacity constraints or context-specific communication norms.

Local policymakers exhibit a different pattern, with online dissemination emerging as the dominant format, followed by direct and then official channels. Their communication targets mirror those of subnational actors - ministries, civil society, scientific institutions, and subnational bodies - but the reliance on online channels suggests either resource-driven pragmatism or an intentional strategy to increase information accessibility. The relatively limited use of official formats may reflect weaker institutional embeddedness or fewer obligations for formal reporting.

Taken together, Finland's public authorities demonstrate a high degree of institutional pluralism. Ministries and national agencies maintain structured, multidirectional knowledge flows that emphasize formal coordination while remaining open to informal and digital dissemination. Subnational and local bodies, while engaging a broad set of recipients, tend to favour direct or online formats, underscoring the importance of informal networks and digital infrastructures in multilevel governance. One cross-cutting feature is the consistent targeting of scientific institutions and civil society actors, suggesting an inclusive approach to science-policy interface. However, think tanks remain relatively peripheral across all public authority flows, indicating a possible gap in engagement with epistemic intermediaries. Overall, the data reflect a mature, multi-format national knowledge system with some asymmetries in institutional capacity and connectivity across governance levels.

II. Scientific/ Research Actors and Multipliers

In Finland, scientific institutions emerge as prominent information providers, with a relatively balanced distribution across direct, official, and online formats. Online channels constitute the single largest share of outgoing flows, followed closely by direct exchanges and then official formats. Scientific institutions provide information most frequently to other scientific bodies, as well as to policy-related entities including other ministries, the Ministry of Biodiversity and Climate, and subnational policymakers. Private and public interest groups also receive a notable share of knowledge from these institutions, though to a lesser extent. The prominence of online and official communication with government entities suggests a strong alignment with procedural and institutional channels, reinforcing the role of scientific institutions as both credible sources and structured contributors to formal decision-making processes.

Multipliers, including knowledge brokers and training or extension services, show a strong reliance on direct formats for disseminating information. Their communication is heavily skewed toward direct exchange, with minimal engagement through official channels and modest use of online formats. These actors primarily direct their knowledge flows toward public interest groups, scientific institutions, and subnational policymakers. While they also reach private interest groups and think tanks, the volume is comparatively lower. The preference for direct formats and targeted dissemination toward implementation and intermediary actors underscores the multiplier role of these institutions in bridging applied knowledge and on-the-ground action. However, the relatively limited use of official and online formats may constrain their reach within higher-level policymaking arenas.

III. Interest and Advocacy Groups

In Finland, Public and Private Interest Groups both played a prominent role as information providers across the network, utilizing all three communication formats—direct, official, and online—with relatively even proportions, although direct communication dominated in both cases.

Public Interest Groups most frequently conveyed information through direct channels, followed closely by online and official formats. Their primary recipients included Public Interest Groups themselves (i.e., internal civil society circulation), as well as Ministries, Agencies, and Scientific Institutions. Information was also shared to a moderate extent with Subnational Policymakers and Think Tanks. This distribution suggests that Public Interest Groups act as important intermediaries and advocates, engaging both with state actors and the broader knowledge and advocacy ecosystem. The diversity of formats used reflects both formalized

policy engagement and more flexible civil society networking. The substantial use of online formats may indicate a preference or necessity for wider public dissemination and transparency.

Private Interest Groups, including businesses and sectoral associations, also showed a broad distribution of information flows across actor categories. Similar to Public Interest Groups, they most frequently used direct communication, followed by online and then official channels. Their strongest information provision was directed toward other Private Interest Groups, indicating horizontal exchange within the private sector. However, Ministries, Agencies, and Scientific Institutions also featured prominently as recipients, suggesting the sector's embeddedness in policy-relevant knowledge exchange. Notably, Private Interest Groups provided more information to policymakers at both national and subnational levels compared to some scientific actors, reflecting their strategic interest in influencing decision-making processes. The tripartite use of direct, official, and online communication formats underscores their role in both formal institutional consultations and informal influence-building efforts.

Together, these findings show that Interest and Advocacy Groups in Finland are central actors in biodiversity and climate knowledge exchange. They not only serve as recipients but also as active disseminators of information, using a variety of channels to reach diverse policy and knowledge communities. Their cross-sector engagement and format versatility position them as key actors at the science-policy-society interface.

IV. Think Tanks and Capacity Building Organisations

Think Tanks in Finland show a relatively balanced use of direct, official, and online formats to share information, with a slight preference for official formats. Their information reaches a diverse array of actors, including public interest groups, private sector stakeholders, and other think tanks, as well as scientific institutions and ministries. Notably, their outreach to ministries is less pronounced than to non-state actors, suggesting a role more focused on interfacing with epistemic or civil society actors than shaping internal government processes. The presence of online flows toward scientific institutions and subnational policymakers reflects a channel for indirectly influencing decision-making through intermediaries rather than direct lobbying of national authorities.

UN Organizations emerge as a key provider of information, especially through online formats, which dominate their communication profile. They disseminate information to nearly all actor categories, with particularly prominent flows toward scientific institutions, public interest groups, and subnational policymakers. Official formats are also significant, especially in their communication with ministries and private sector actors. Direct exchanges are relatively limited, reflecting the role of UN bodies as global knowledge distributors rather than embedded national policy actors. The pattern illustrates their function in agenda-setting and informing cross-cutting policy debates, but also underlines the potential gap in fostering contextualized dialogue or co-production with national institutions.

3.4.3.3 Links between Organizations

While the previous visualizations focus on interactions between actor categories and aggregate flows across formats, the chord diagram offers a more granular view of information flows between specific organizations named by respondents. This chord diagram lays out the specific institutional actors named by respondents. Blue ribbons show "Respondent ← Provider" links (i.e. who respondents report receiving information from), while red ribbons show "Respondent → Recipient" links (i.e. who respondents pass information to). Ribbon thickness is proportional to the number of mentions, and we omit any single-mention ties so that only the most frequently cited connections remain, making it easy to spot which organizations serve as key information sources versus key disseminators. The same chord diagram repeats for all the country cases.

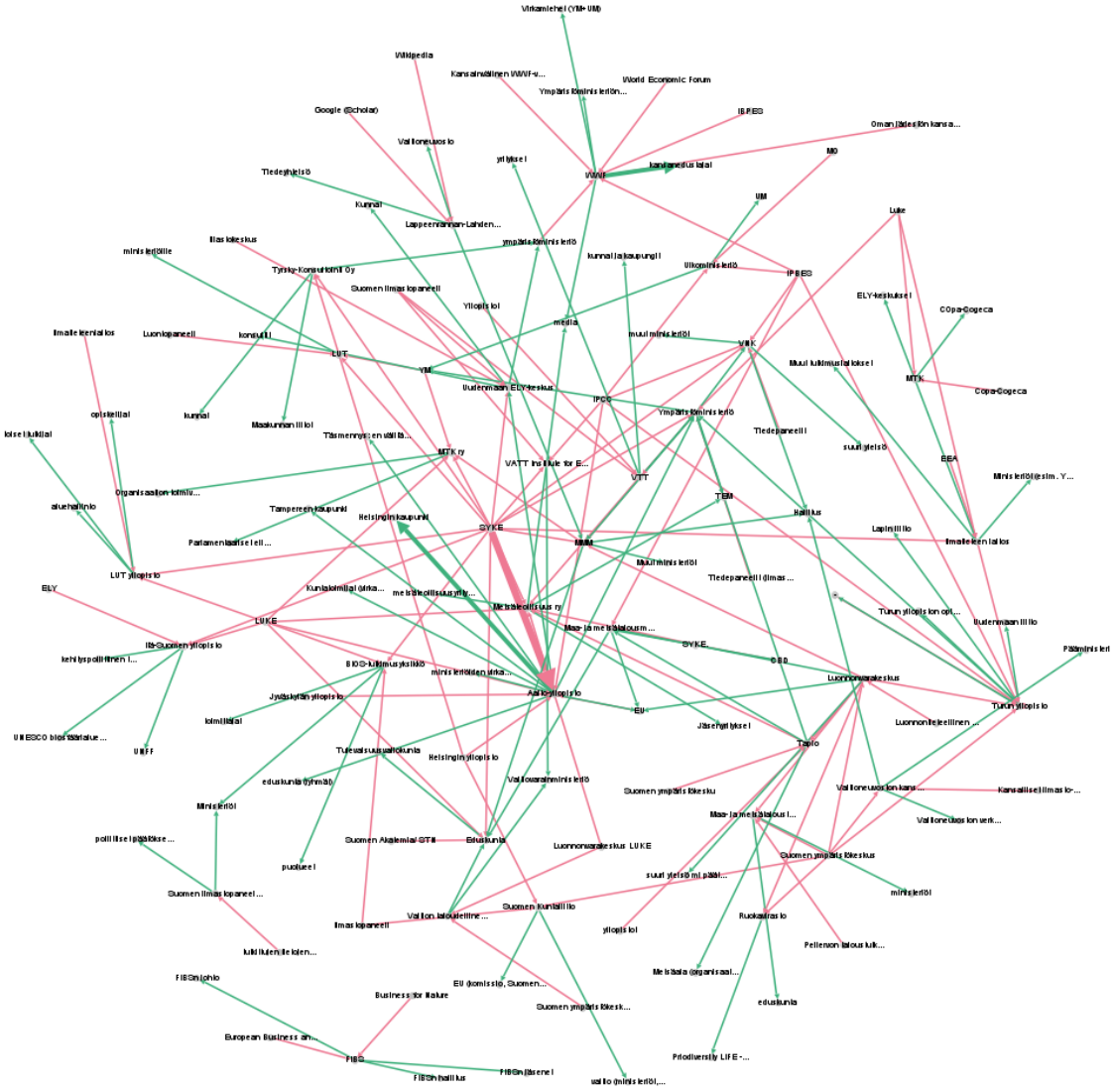

Figure FIN-11: Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.

This SNA map presents the directed information flows among surveyed organizations in Finland's biodiversity–climate knowledge system. Nodes represent organizational entities; arrows indicate the direction of reported information flows, from provider to recipient. Edge thickness reflects normalized frequency of mentions. The figure is based on respondent answers to a targeted question set on who they send and receive information from, enabling structural insight into how knowledge is circulated within the Finnish science-policy interface.

The network shows a relatively dense and multi-nodal configuration, with no single institution dominating both the provision and reception of information. Instead, the structure reveals a role-specialized system, in which scientific institutions are primarily cited as providers, political and administrative institutions as recipients, and ministries occupy a mediating position.

At the core of the network is the Finnish Environment Institute (SYKE), which emerges as the most prominent outward-facing knowledge provider. SYKE is connected to a wide array of actors but receives

relatively few incoming ties, suggesting a role focused on scientific dissemination rather than iterative exchange. Other research-oriented institutions, including LUKE (Natural Resources Institute Finland) and university-affiliated bodies, also appear with strong outward flows and minimal incoming ties, reinforcing the central role of national science institutions in the Finnish evidence ecosystem.

The Ministry of the Environment (YM) appears as a moderately central node with bidirectional ties, suggesting its role as both a recipient of scientific inputs and a conduit for relaying information further to other governmental or political actors. However, the degree of centrality is lower than might be expected in a fully integrated or top-down system, suggesting a distributed governance model in which ministries absorb knowledge but do not tightly control its onward distribution.

High-level political institutions, including Eduskunta (Finnish Parliament), Hallitus (Government), and the EU are positioned primarily as information recipients, with incoming arrows but limited or no outward ties. This pattern reflects a top-tier policy audience role, where actors are targeted for influence but are not perceived as contributors to horizontal knowledge exchange.

Global expert platforms, such as the IPCC, IPBES, and the Finnish Climate Panel, are largely outward-facing in this network, cited as sources of information but not recipients. Their structural position underscores their epistemic authority, but also points to a lack of formalized feedback loops or deliberative engagement within the domestic knowledge system.

The broader network configuration - marked by numerous moderate-sized nodes, overlapping edges, and the absence of isolated clusters - suggests a relatively mature and institutionalized interface, but one that remains functionally segmented. Scientific expertise flows toward policy centers, while political actors are addressed as audiences, not contributors. There is limited evidence of horizontal peer exchange or cross-sector deliberation among civil society, private sector, or local governments.

In sum, Finland's biodiversity–climate knowledge system, as represented here, reflects a modular and specialized structure: scientific institutions produce, ministries mediate, and political institutions receive. This configuration supports high technical credibility and organized outreach but leaves space to improve reciprocal exchange, horizontal integration, and feedback-driven learning[4].

[4] As with other countries, the Finland survey focused on governmental actors, science-policy intermediaries, and civil society. While several research institutions are visible, the absence of many academic universities or media organizations reflects the design of the sampling frame and should not be interpreted as lack of engagement.

3.4.4 Facilitation and Improvement of Knowledge Exchange

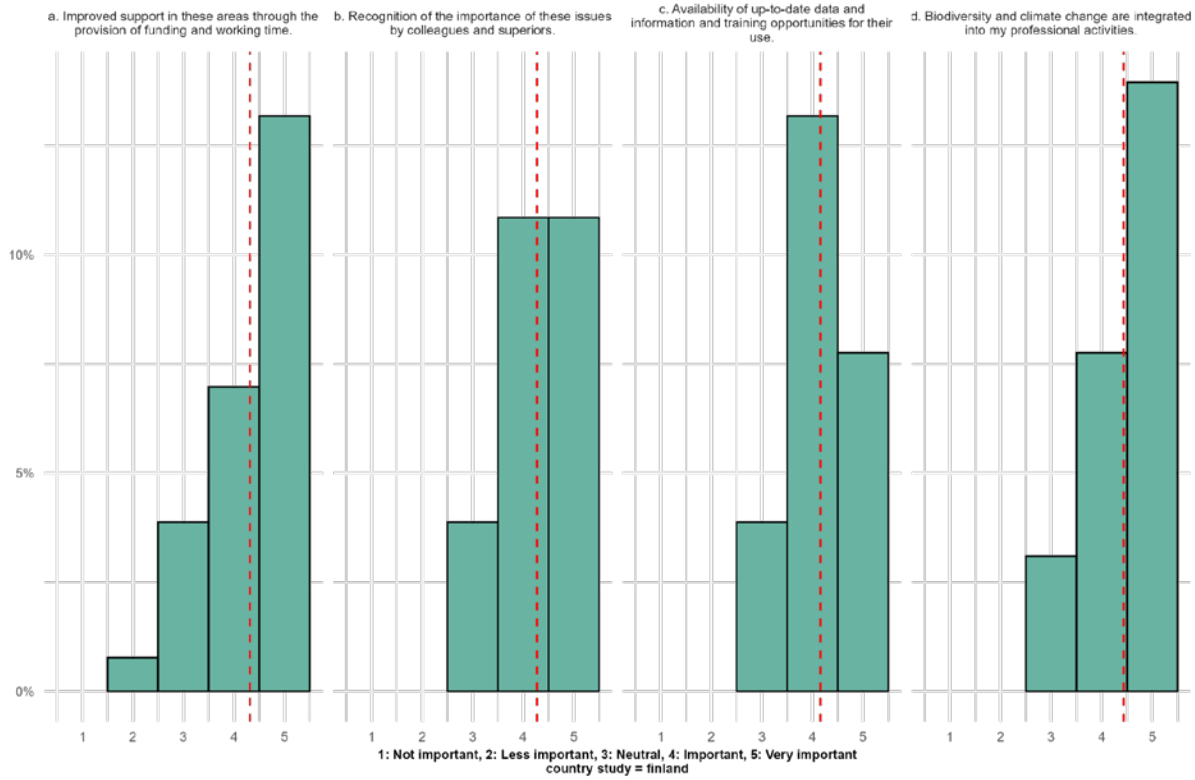

Figure FIN-12. Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

The figure presents respondent agreement (on a scale from 1 to 5) with four statements related to knowledge exchange on biodiversity and climate change. The overall results indicate strong positive perceptions, with all four statements receiving high levels of agreement, as reflected in the mean scores, which range from 4.27 to 4.44.

The highest agreement is with the statement that *"biodiversity and climate change are integrated into my professional activities"*, with a mean of 4.44. This suggests that Finnish respondents perceive these issues as well embedded in their day-to-day professional mandates, signaling alignment between environmental concerns and organizational roles. Similarly, respondents strongly agree that they *receive support through funding and working time to engage with biodiversity–climate issues*, with a mean of 4.31, indicating that institutional support mechanisms are generally in place and perceived as enabling.

The lowest scoring item, though still positively rated, concerns *recognition of the importance of biodiversity and climate change by colleagues and supervisors* (mean 4.27). While high, this score slightly lags behind others, possibly indicating that internal organizational culture or interpersonal validation may not be as robust as the structural or procedural integration of these issues. Finally, agreement with the *availability of up-to-date data and training opportunities* also scored high (mean 4.43), reinforcing the notion that respondents feel well-resourced in terms of informational inputs and capacity development.

These findings collectively suggest that Finland presents a highly supportive environment for knowledge exchange on biodiversity and climate change. Not only are these themes institutionally embedded, but respondents also perceive material support, access to relevant knowledge, and opportunities for capacity-building. The relatively lower, but still strong, agreement on social or peer recognition suggests room for strengthening interpersonal and cross-departmental reinforcement of these values. The consistency of

responses across all four statements may reflect Finland's long-standing integration of environmental issues in public governance and research systems.

Preferences for Strengthening Cooperation and Information Exchange

Resources: Resources (time and money) and their division central both at the producing end and at the receiving end of information., information should be linked to practical examples

Popularisation of scientific information and public engagement: Strengthening public awareness through the media should be pursued vigorously. Popularising scientific knowledge: Scientists need to bring difficult-sounding knowledge into the public arena – "we need Finland's Attenboroughs". The decision-making process is not separate from public communication. Involving young people in decision-making, more funding for environmental education. Bottom-up type of dissemination can create motivation to focus on climate change and biodiversity in decision-making. I would like to see NGOs and nature organisations, for example, investing in communicating with citizens, especially before elections.

Disseminating the latest information and policy recommendations to all professional levels: The information should be processed in a form that is accessible. Clarifying the main messages of scientific knowledge is key. For example, it should be possible to produce policy recommendations in all research projects. There should be skills and time to do this. It is not necessarily enough for researchers to do it, there should be people who understand the substance, but their role is to compile the material into a usable, understandable form. Information on climate change and biodiversity should be put in a form that is relevant to the decision-making documents that decision-makers normally use. Now often separate studies etc., i.e. integration in the actual decision-making situation, are not done. In general, it is good if universities and research institutes maintain websites to find out which experts are able to respond to which topics. During the Corona period, this information could be found in corona experts in aggregated form, and was quite useful.

Links to other topical themes: Climate and nature issues must be cross cutting themes in decision-making processes. The topics must also be better linked to hot topics at EU level and national level: sustainable growth, competitiveness & clean industry. The importance of tackling climate change and promoting biodiversity should be recognised by organisations outside the natural resources sector or those closely linked to these themes. Integrating economic impacts into the analysis. Biodiversity: reconciling data from different perspectives to achieve overall sustainability.

Polarisation and the role of science: Confidence in science and research should be strengthened. Emphasising that fact and science should be the basis for action. We also need to pay attention to how we deal with researched data in this political environment.

Lack of motivation across different interest groups on a political level. Different interest groups would need to have the interest and motivation to seek and use the knowledge themselves. Attitude change and a political consensus (including interest groups) is needed that mitigation of biodiversity loss and climate change is in the interest of all actors in society. It is important to see what kind of example and message the state and different ministries show here. The problem may not be that scientific knowledge does not reach the decision-makers, but that the decision-makers are not obliged to react to the knowledge, but that it is like water off a goose's back.

In terms of influencing political decision-making, the timing and targeting of information provision is critical. Respondents stressed the need to monitor legislative processes in order to anticipate when policy packages will be introduced and provide relevant ministries with timely research findings and expert lists for both ex-ante and ex-post impact assessments. Once proposals move to parliament, expert support should also be extended to parliamentary actors. NGOs and nature organizations were encouraged to actively shape party and government programmes. These processes would benefit from insights into future scenarios, including qualitative estimates of costs, particularly the costs of inaction, and clearly communicated evidence on potential policy solutions.

The key people in the decision-making processes should be willing to receive the relevant information that is out there. Decision-makers should be required to justify how they have taken research evidence into

account in their decision-making (or explain in plain language why they are deciding against research-based recommendations). Timely access for researchers to communicate research evidence is difficult, hence there should be mechanisms to make this easier or clearer for researchers. Some kind of feedback on how research evidence has influenced the preparation and decision-making process would also be helpful.

In Finland, SYKE (the Finnish Environment Institute) functions in practice as the national biodiversity agency, while the Finnish Meteorological Institute (Ilmatieteen laitos) serves as the de facto climate agency. The Ministry of the Environment holds overall responsibility for both biodiversity and climate-related matters. Though this division is somewhat simplified, it aligns with an agreed-upon operative framing among key stakeholders. Respondents emphasized the importance of cooperating with these agencies, as well as with Finnish science panels such as the Finnish Climate Change Panel and the Expert Panel for Sustainable Development. More broadly, collaboration with universities, ministries, national agencies and bureaus, and subnational actors like cities and municipalities was seen as essential. EU-level and international cooperation were also highlighted as important.

Preferred formats for knowledge exchange included joint fact production/co-production (e.g., researchers working directly with municipalities), direct collaboration based on strong interpersonal connections, workshops, seminars, and webinars, as well as timely and accessible information. Respondents called for targeted tools, for example, a more tailored version of Climateguide.fi designed specifically for subnational actors, and the regular dissemination of reports and relevant publications to ensure that science-policy interfaces are well-supported.

3.5 Germany

3.5.1 Information on Respondents

In Germany in total 51 respondents completed the survey. The most commonly reported role is "forwarding or communicating information" (approx. 37 respondents), indicating that many participants act as knowledge intermediaries, facilitating internal organizational flow rather than directly making or shaping external decisions. Technical expertise provision is also high (approx. 33 respondents), aligning with the overrepresentation of research actors and suggesting that analytical and evidence-based input is a common form of contribution in the German context. Fewer respondents (approx. 26) report direct decision-making roles, implying that knowledge users in governance positions may be underrepresented relative to producers and intermediaries. This has implications for interpreting subsequent SNA maps, indicating to an extent that dense information flows may not translate directly into uptake within policy processes. For further actor specific distribution see figures in the Appendix.

3.5.2 Network

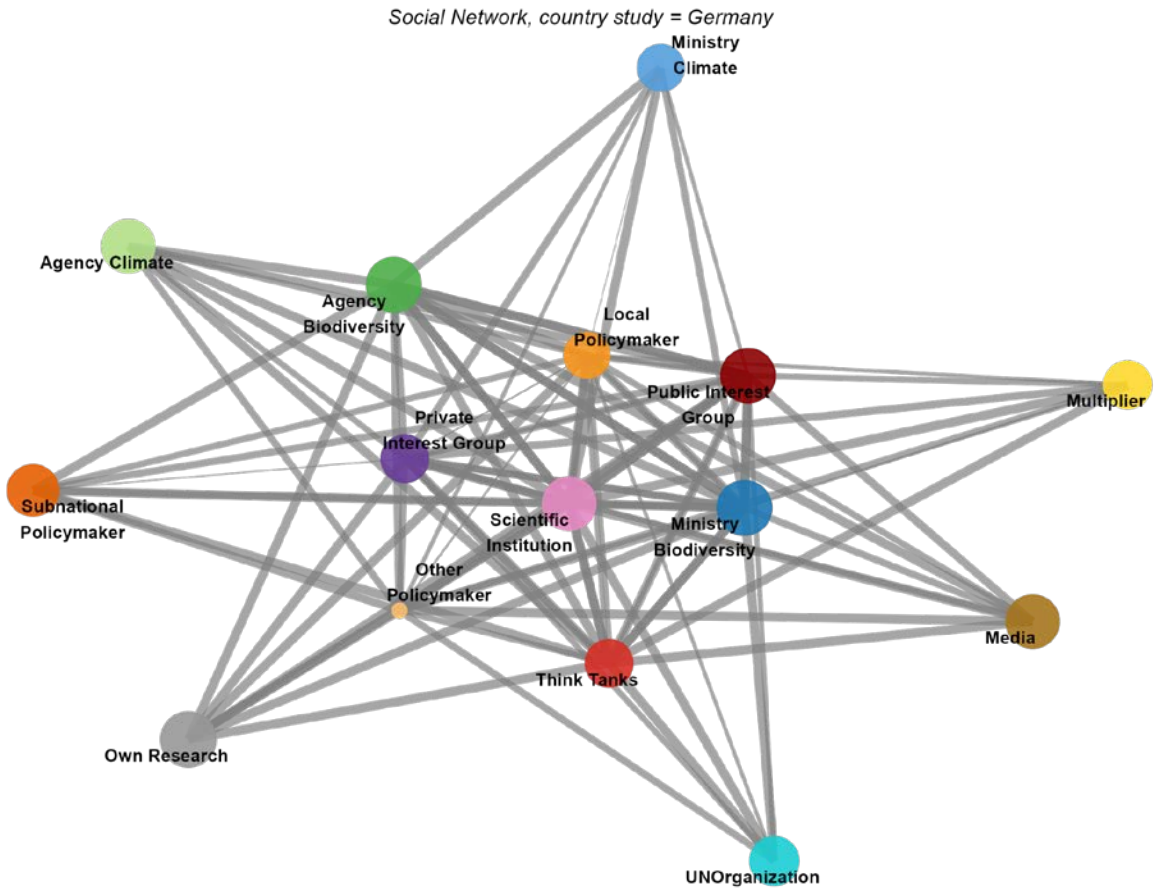

Figure GER-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Germany.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	InDegree	OutgoingFlow	Betweenness

AgencyBiodiversity	8	7.77	0.000916
MinistryBiodiversity	8	7.77	0.0101
PublicInterestGroup	8	7.61	0.0101
ScientificInstitution	8	7.32	0.0101
AgencyClimate	8	7.19	0
Media	8	7.17	0
OwnResearch	8	7.90	0
SubnationalPolicymaker	8	6.55	0
LocalPolicymaker	7	4.73	0.000916
PrivateInterestGroup	7	5.25	0.000916
ThinkTanks	7	5.26	0
MinistryClimate	7	4.98	0
Multiplier	7	5.29	0
UNOrganization	7	5.65	0

Metric	Value
Total Nodes	15
Total Edges	106
Number of Isolates	1
In-Degree Centralization	0.067

The SNA map for Germany reveals a highly connected and moderately decentralized knowledge system, where public authorities, scientific bodies, and civil society actors are widely recognized as biodiversity–climate information providers. The network comprises 15 actor types and 106 directed ties. This indicates that information provision is relatively evenly distributed across actor groups, with no single actor type monopolizing visibility.

Eight actors receive the maximum in-degree score (8), meaning they were named by all respondent groups as sources of information. These include the Ministry of Biodiversity, Agency for Biodiversity, Agency for Climate, Scientific Institutions, Public Interest Groups, Media, Own Research, and Subnational Policymakers. Their high normalized outgoing flow scores (ranging from 6.55 to 7.90) reflect both frequency and consistency of perceived knowledge provision across respondent categories.

Among these, Scientific Institutions (flow = 7.32), Public Interest Groups (7.61), and the Ministry of Biodiversity (7.77) stand out not only for their visibility but also for their structural role within the network. Each of these actors records the highest betweenness centrality (0.0101), indicating that they serve as modest but non-trivial bridging actors, facilitating indirect connections between otherwise separated parts of the network. These actors likely link scientific, civil society, and policymaking communities in Germany's environmental governance context.

Other central actors such as Own Research (flow = 7.90) and Agency for Biodiversity (7.77) demonstrate high information provision but do not perform bridging functions (betweenness = 0). This pattern suggests that while they are widely acknowledged as providers, they do not connect across actor group boundaries in the same way as Scientific Institutions or Public Interest Groups.

Several actor types maintain strong participation but lower levels of structural influence. Private Interest Groups, Local Policymakers, and Think Tanks show in-degree values of 7 and moderate flows (4.73 to 5.26), but low or negligible betweenness, indicating that their role is largely one of provision within defined circles, without cross-sectoral coordination. UN Organizations, Multipliers, and the Ministry of Climate

follow similar patterns—present, cited, and engaged, but structurally peripheral in terms of network bridging.

The single isolate, "OtherPolicymaker," was not cited by any respondent group, suggesting a gap in either institutional visibility or respondent familiarity. Its presence underscores the importance of clarifying actor categories in future surveys or expanding sampling to capture more nuanced subnational variation.

At the structural level, Germany's network highlights a knowledge system where formal institutions dominate visibility, particularly governmental ministries and agencies. However, the presence of civil society and scientific actors in top provider and bridging roles reflects a degree of plurality and collaboration. Scientific Institutions and NGOs, in particular, act as connective tissue, linking public and non-state actors in the broader information ecosystem. At the same time, the relatively low betweenness scores across the network suggest that while many actors are active, deeper cross-sectoral integration or co-production mechanisms may remain limited.

These findings emphasize Germany's reliance on formal, institutionalized sources of biodiversity–climate knowledge, while also suggesting openings for strengthening horizontal exchange and the role of less visible actors, such as private sector entities and local policy stakeholders, in national-level knowledge systems.

3.5.3 Information Flows

3.5.3.1 Information Flow by Format

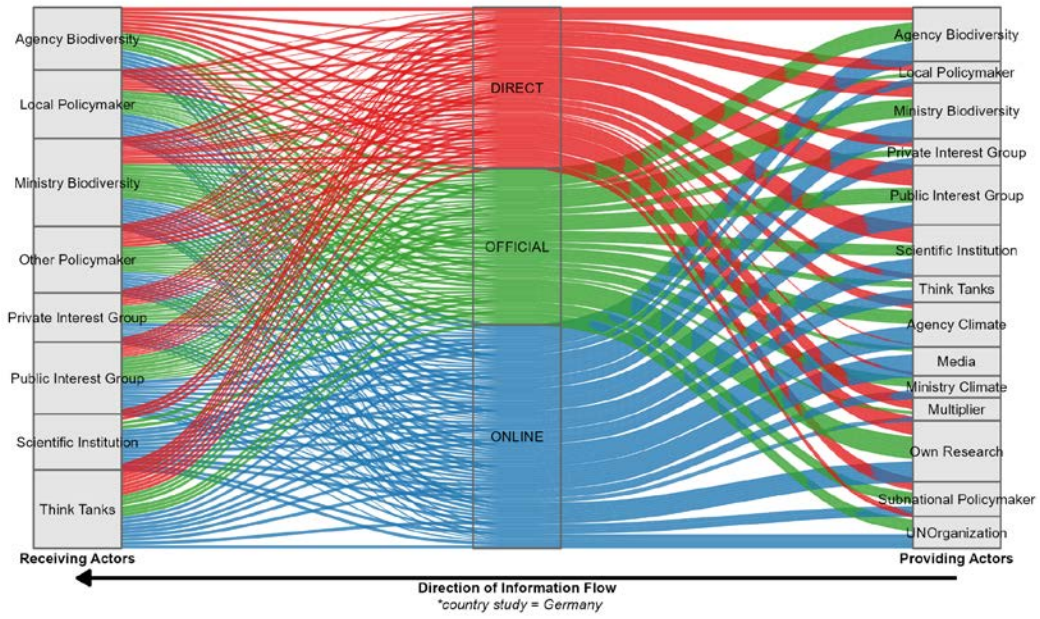

Figure GER-2. Format-specific Sankey diagram showing how information from providers reaches receivers in Germany, segmented into three formats: Digital and online media (websites, social media, newsletters); Official and formal documents (reports, summary for decision-makers, IPCC reports, IPBES reports, information sheets) and Direct and indirect communication (emails, phone calls, expert advice, workshops, conferences)

This Sankey diagram illustrates how biodiversity–climate information flows across actor categories in Germany, disaggregated by communication format. On the left, provider actor types are listed; on the right, the recipient actor categories. The middle column shows the three communication formats through which information is received: Red: Direct and indirect communication (e.g., emails, phone calls, expert advice, workshops, conferences); Green: Official and formal documents (e.g., reports, summaries for decision-

makers, IPCC/IPBES outputs) and Blue: Digital and online media (e.g., websites, social media, newsletters).

The width of each ribbon reflects the relative frequency with which respondents indicated receiving information in that format from a given provider type. The proportions are normalized across all providers, meaning this diagram does not reflect volume alone but rather the distribution of formats per actor type. The same repeats for each country case discussed in the report.

1. National Ministries and Government Agencies: These actors (MinistryBiodiversityClimate, AgencyBiodiversity, AgencyClimate) distribute information primarily through official formats (green) and, to a lesser extent, digital/online media (blue). Direct formats (red) play a minor role in their communication profile. This pattern indicates that written outputs and formal documents are preferred modes of engagement. The secondary use of digital platforms shows a commitment to transparency, though it may remain impersonal or one-directional. The limited use of direct exchanges suggests that interactive policy dialogues or advisory exchanges with these institutions may be structurally constrained.

2. Scientific Institutions: This actor group shows substantial use of online, official, and direct formats. They appear to distribute information almost evenly across the three modes, with a slight dominance of digital dissemination. This pattern indicates the dual role of scientific institutions as both producers and translators of knowledge. Their use of direct formats likely includes participation in workshops, consultations, or expert networks, while their official outputs may include scientific reports, position papers, and policy briefs. The inclusion of policy briefs, which are distinct from position papers in their conciseness and audience targeting, highlights their active role in tailoring science for decision-makers. Their engagement across formats suggests institutional adaptability and a potential bridging role in the German knowledge system.

3. Public and Private Interest Groups: Public Interest Groups rely more heavily on digital and direct communication, while Private Interest Groups show a relatively stronger presence in direct and official formats. This pattern indicates that civil society actors prioritize accessibility and interpersonal outreach, which may reflect campaign-driven communication, community mobilization, or advocacy through workshops and forums (more?). Private actors engage through formal documents and direct contacts, which is consistent with lobbying practices or participation in regulatory consultations (CITE).

4. Think Tanks: Think Tanks primarily disseminate information through online formats, followed by some use of official channels. Direct communication plays a minor role in their communication strategy. This pattern suggests that think tanks operate primarily as public knowledge disseminators, publishing through digital channels and policy documents. Their relatively low use of direct formats implies that they are not functioning as close policy intermediaries or embedded advisors within the biodiversity–climate domain. Instead, their role may be more aligned with agenda-shaping through public or institutional analysis, rather than through participatory or consultative engagement with ministries or agencies.

Recipients: Ministries and Scientific Institutions appear as the most common recipients across all three formats. Public and Private Interest Groups also receive substantial flows, particularly through direct and online formats. Think Tanks and Subnational Policymakers receive a narrower range of information and appear slightly less connected.
The centrality of ministries and research institutions as recipients indicates their key position in policy-relevant knowledge uptake. The relatively lower information reception by subnational actors suggests a vertical disconnect, which may be significant in a federal system like Germany's where implementation happens at multiple governance levels.

3.1.3.2 Receiver-Specific Information Flow

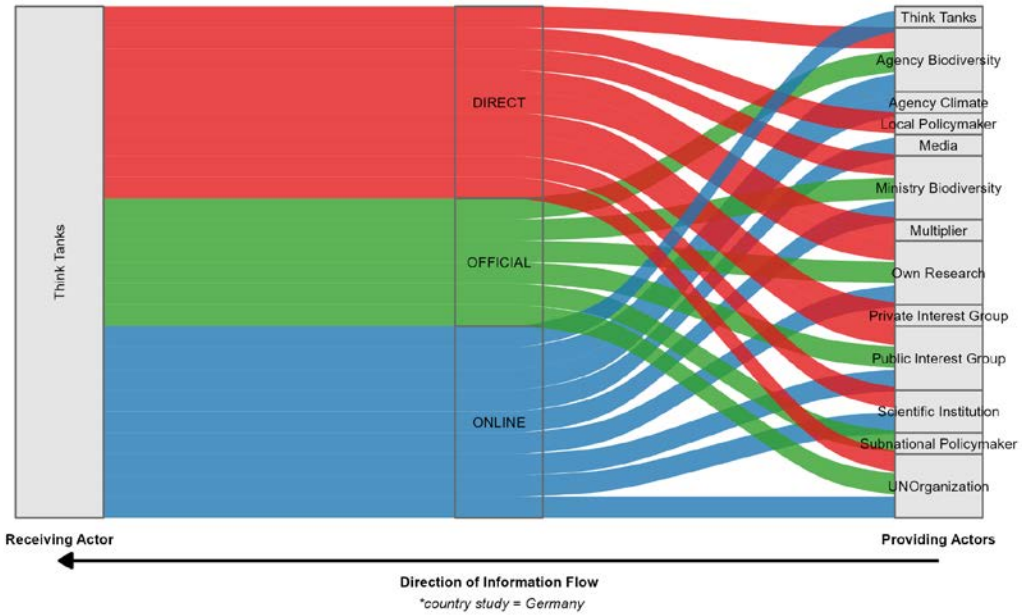

Figure GER-3. Receiver-Specific (Think Tanks) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

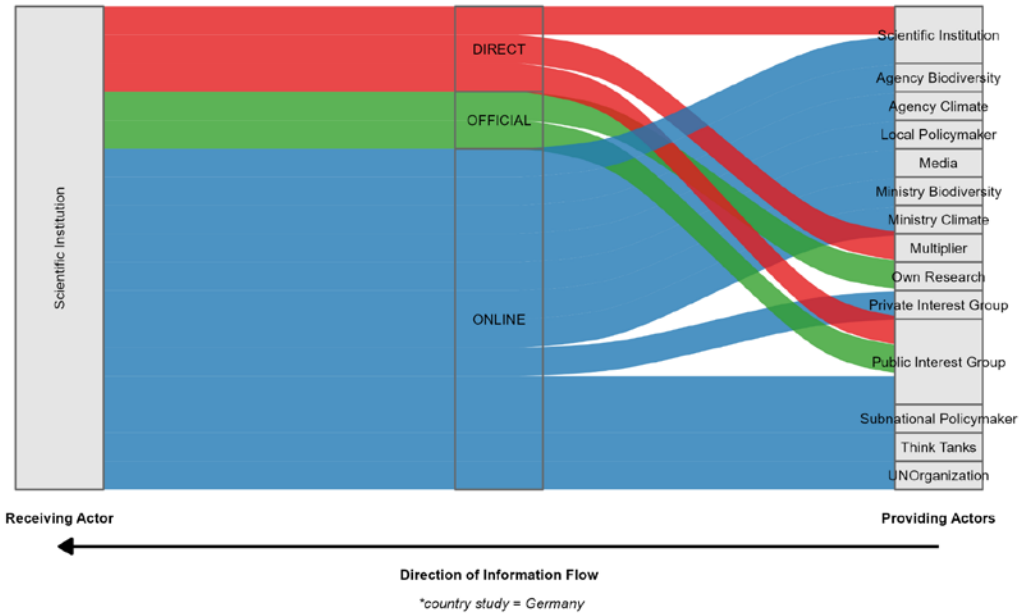

Figure GER-4. Receiver-Specific (Scientific Institution) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

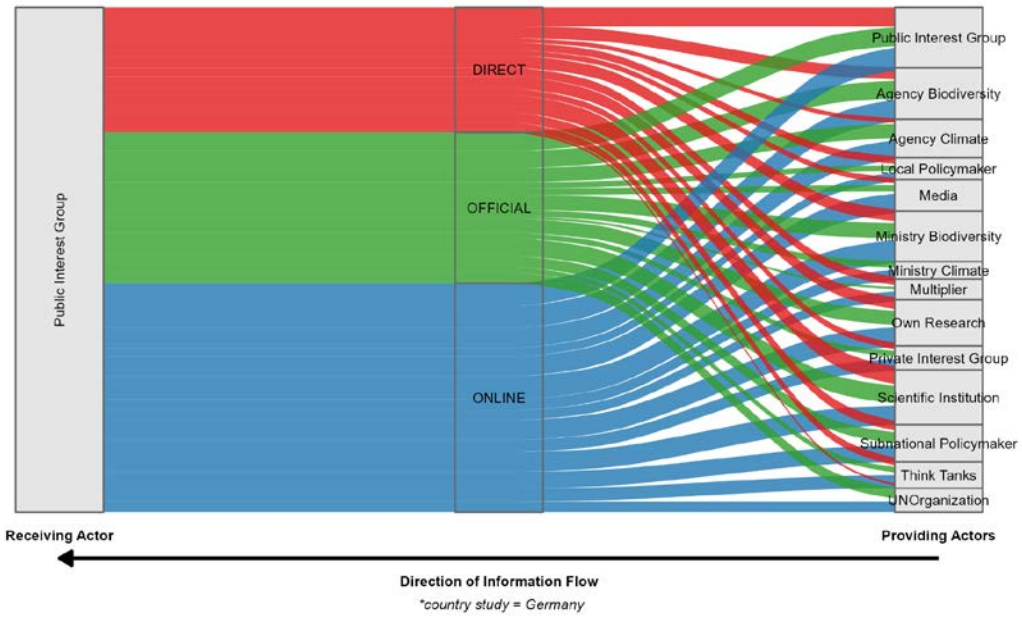

Figure GER-4. Receiver-Specific (Public Interest Group) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

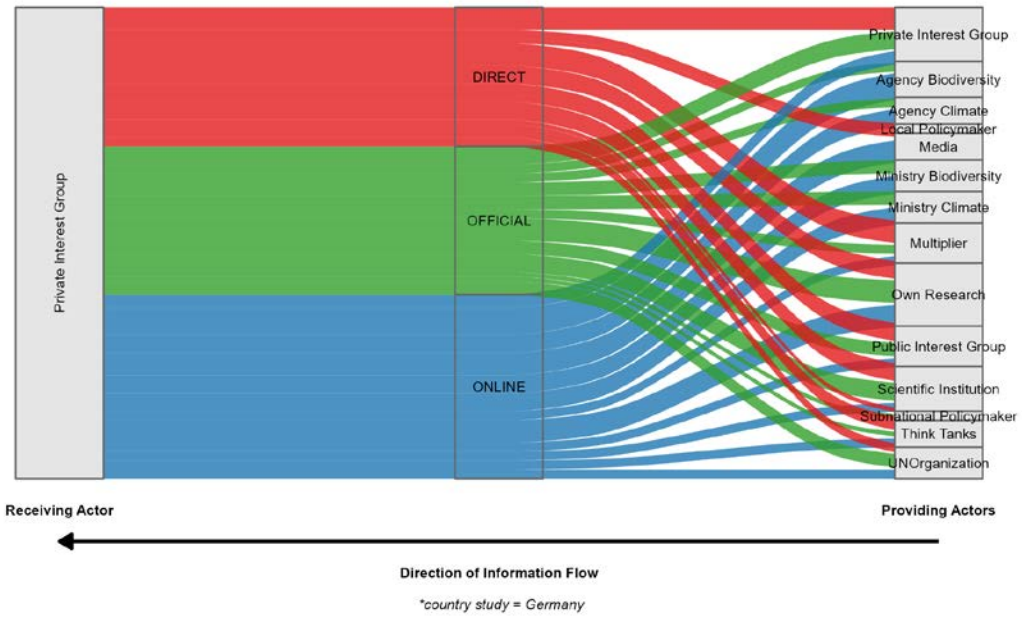

Figure GER-5. Receiver-Specific (Private Interest Group) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

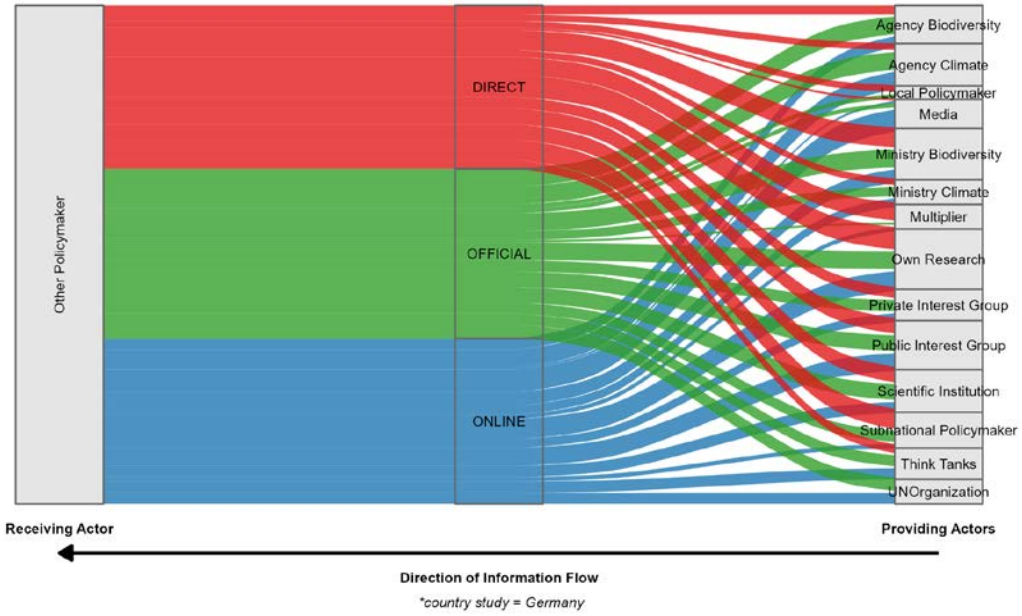

Figure GER-6. Receiver-Specific (Other Policymaker) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

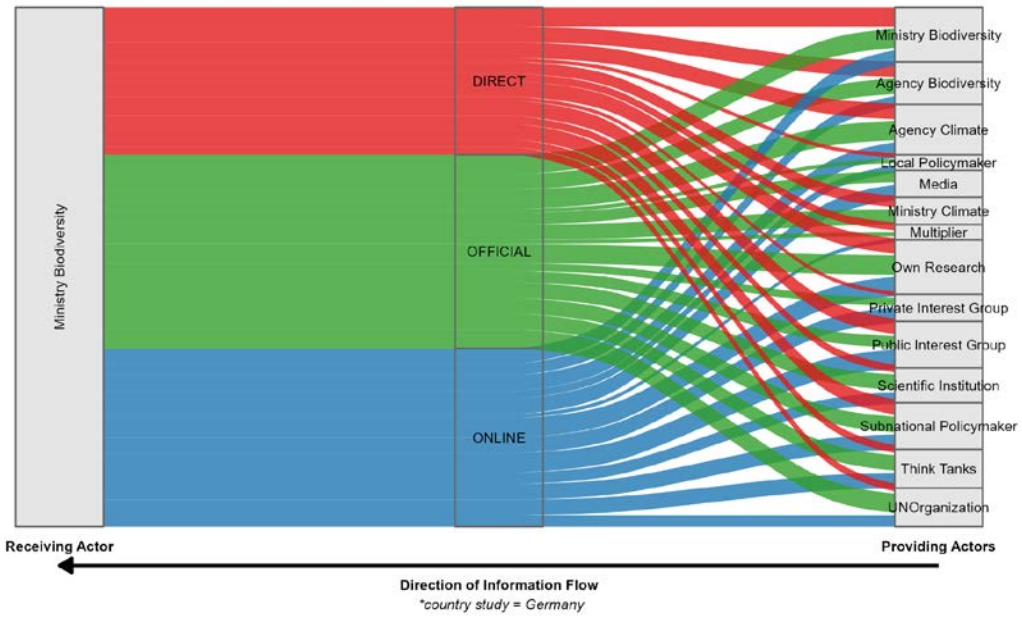

Figure GER-7. Receiver-Specific (Ministry responsible for Biodiversity) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

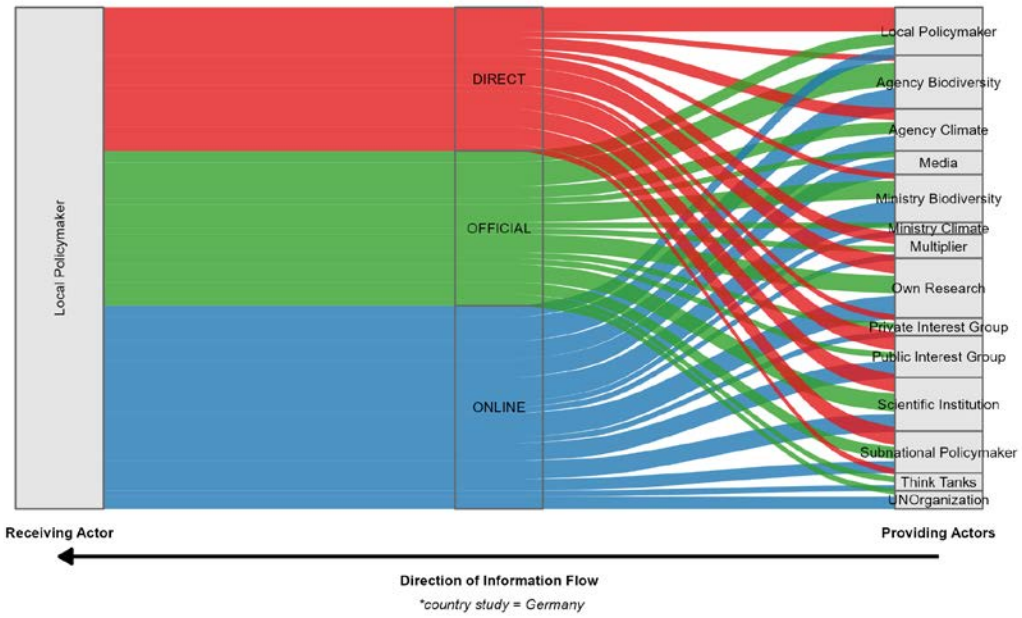

Figure GER-8. Receiver-Specific (Local Policymaker) Information Flow in Germany, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

MinistryBiodiversity and MinistryClimate both distribute information across a wide array of actor groups using all three formats. Notably, MinistryBiodiversity shows high proportional engagement with other ministries and public interest groups, particularly via official and online channels. In contrast, MinistryClimate appears slightly more limited in reach, with direct communication formats less prominent. Direct communication stays mainly in political field at federal level (e.g. Ministry of Biodiversity, Agency responsible for Biodiversity, Other Policymaker), which implies that there is a lot of internal communication. Private interest groups are not in an intensive information exchange with the Ministry of Biodiversity. The Ministry of Climate mainly informs other actors in the political field, among others the Ministry of Biodiversity. This means that there is an exchange of information across Ministries.

National Agencies in Germany prefer online and official formats. The Agency for Biodiversity (BfN) has a slightly higher outreach than the Agency for Climate (UBA). AgencyBiodiversity (BfN) is a strong provider via official channels, especially to Ministries and Scientific Institutions, while AgencyClimate (UBA) demonstrates more engagement through direct formats, including with public interest groups and think tanks.

SubnationalPolicymakers and LocalPolicymakers have a smaller information footprint overall. When they do provide, it is mostly through direct or official formats, often targeting Ministries or Scientific actors, reflecting localized governance engagement but a narrower dissemination base. Remarkably Private Interest Groups nearly do not use Subnational Policymakers as information providers.

On a local policy level, the prevalent formats to provide information are direct formats and online formats. There is no information flow from local policymakers to the National Agencies. Only from National Agencies to local policymakers (Refer to Sankeys for national agencies).

Public authorities in Germany are key hubs in information flows, with Ministries playing the broadest intermediary roles. Agencies serve more specialized bridging functions, especially to technical audiences. The varied use of formats indicates institutional differentiation, ministries rely more on formal channels, whereas subnational bodies lean on relational or direct communication.

II. Scientific/ Research Actor and Knowledge Intermediaries

Scientific Institutions are information providers, particularly to Ministries, Agencies, and Public Interest Groups. Their preferred format is online, followed closely by official channels. Multipliers or knowledge intermediaries (e.g., training/extension organizations) mainly communicate through a direct format. Unsurprisingly online communication formats have the largest share.

III. Interest and Advocacy Groups

Public Interest Groups (e.g., NGOs) are substantial providers to Ministries, Scientific Institutions, and other civil society actors. Information is disseminated fairly evenly across online, official, and direct formats, indicating a multi-modal communication strategy. Private Interest Groups show more focused flows toward Ministries and Agencies, with heavier use of direct and online communication, likely reflecting compliance, consultation, or lobbying pathways rather than broad public dissemination. Direct Communication of Private Interest Groups mainly targets other Private Interest Groups and Think Tanks.

IV. Think Tanks and Capacity Building Organizations

Think Tanks primarily provide information to Ministries, Agencies, and Scientific Institutions, using official and online formats. Their relatively focused recipient base suggests targeted influence efforts toward high-capacity actors. Multipliers (e.g. capacity builders, transdisciplinary networks) provide more broadly, particularly to Public Interest Groups and Scientific Institutions, mainly via direct communication. Interestingly there is no direct communication between different think tanks. While both types of intermediaries bridge science and policy, their approaches differ. Think Tanks emphasize formalized knowledge products targeted at elite institutions, while Multipliers engage more directly and interactively with a wider set of actors. Their modest volume of flows, however, indicates that intermediary functions may be underdeveloped or under-recognized in the German landscape.

UN Organizations like IPCC and IPBES are primarily cited as information providers to Scientific Institutions, Ministries, and Think Tanks, almost exclusively using online formats, followed by some official publications. The Ministry of Biodiversity and Think Tanks are important receivers of information. UN bodies play a foundational yet indirect role in Germany's knowledge system. Their dissemination relies on global reports and portals rather than tailored communication. The absence of direct format use indicates limited personalization or bilateral engagement, suggesting that international information is present but not deeply embedded in horizontal national flows.

Cross-Cutting Observations: Ministries, Scientific Institutions, and Public Interest Groups emerge as the most active providers across formats and audiences. Their presence reflects Germany's strong state–science–civil society triangulation in environmental governance. Official formats dominate in interactions involving Ministries and Agencies, while direct channels are more prevalent among NGOs, subnational actors, and private sector providers. Intermediary actors like multipliers and think tanks, while conceptually central to policy translation, are less prominent than expected. Their limited representation may reflect either survey sampling limitations or structural gaps in Germany's knowledge brokering architecture. Overall, Germany's provider landscape is marked by institutional diversity, format pluralism, and relatively symmetrical flows among core public and research actors, though engagement with and from private sector and intermediary actors remains thinner.

3.5.3.3 Links between Organizations

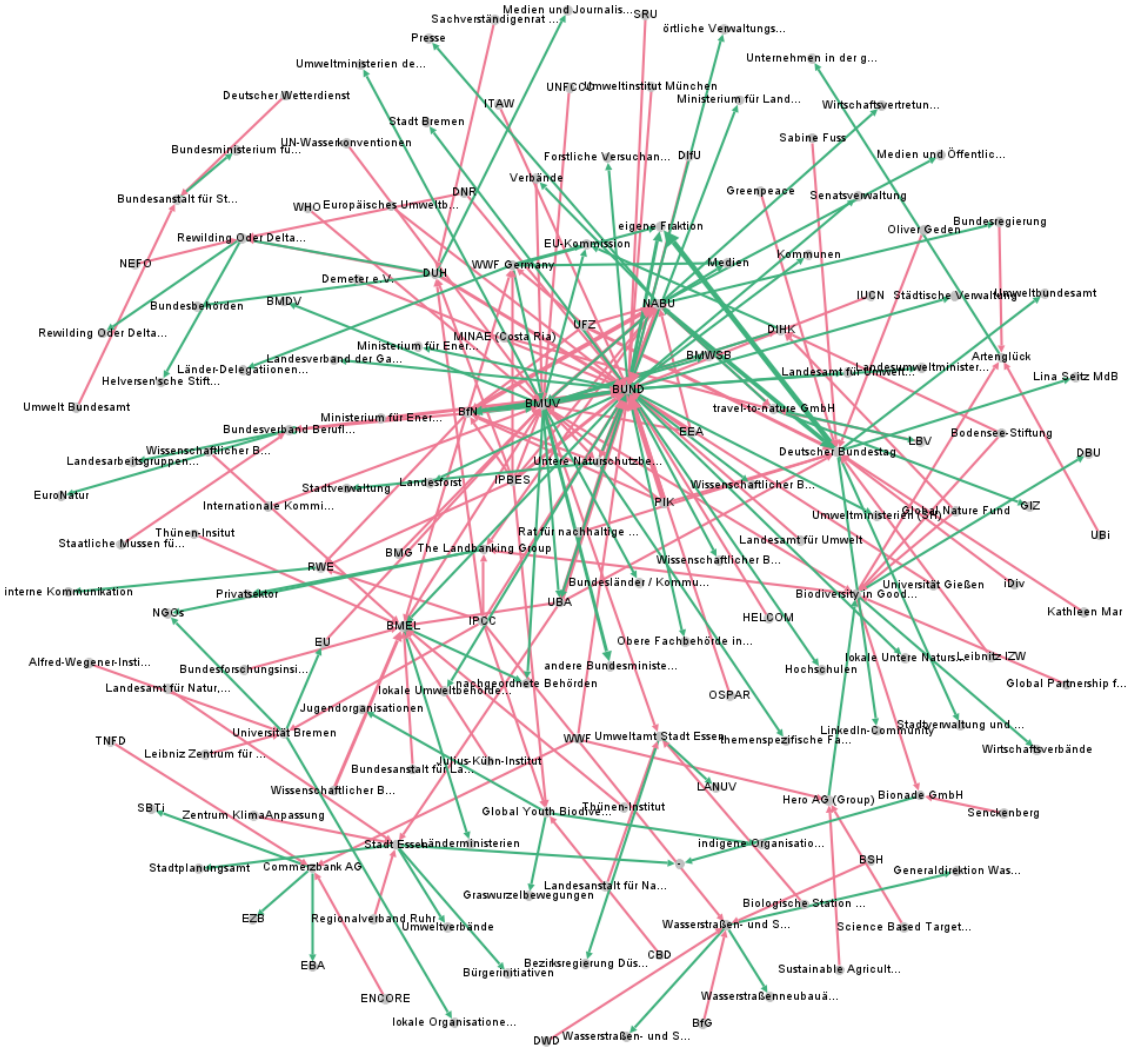

Figure GER-9: Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.

This visualization displays the directed information flows among organizations named by respondents in Germany's biodiversity–climate knowledge system. Each node represents a specific organization or institution; arrows indicate the direction of reported information exchange, from provider to recipient. Edge thickness is proportional to the normalized frequency of mentions, based on responses to a question on who participants send and receive information from.

The network shows a dense but asymmetrical architecture, centered around a few highly connected federal institutions and intermediary actors. The Federal Ministry for the Environment (BMUV) emerges as a multifunctional core actor, with high in-degree and out-degree centrality. It receives information from a wide range of sources, including NGOs, scientific institutions, and implementation bodies, while also

forwarding knowledge to other ministries, sectoral agencies, and international organizations. This confirms its dual role as both policy coordinator and communication node within Germany's biodiversity–climate governance system.

Closely linked to BMUV is the Federal Agency for Nature Conservation (BfN), which also plays a prominent role in both sending and receiving information. BfN's position suggests a bridging function between scientific knowledge production and implementation agencies, and its outward ties reflect its role as a disseminator of policy-relevant content, rather than as a consumer of diverse external inputs.

Environmental NGOs, particularly BUND and NABU, are structurally central in the network and display strong bidirectional ties. These organizations receive scientific and institutional knowledge but also actively forward information to ministries, legislative bodies, and advocacy targets. Their network positioning reflects their status as civil society intermediaries, translating complex content into public-facing or political discourse.

Scientific institutions such as PIK (Potsdam Institute for Climate Impact Research), UFZ (Helmholtz Centre for Environmental Research), and the German Biodiversity Research Centre (iDiv) appear primarily as knowledge providers, with few if any incoming ties. This unidirectional pattern[5] aligns with their role as upstream knowledge producers in the policy-science interface but may suggest limited institutional integration in terms of feedback uptake or horizontal deliberation.

International organizations, including IPBES, IPCC, and the European Environment Agency, are visible as outward-only knowledge sources, reinforcing their influence as global standard-setters and normative authorities. Their positioning reflects alignment with national scientific and policy institutions, but the lack of bidirectional edges underscores the absence of routine feedback mechanisms.

The private sector, subnational governments, and media actors are noticeably underrepresented in the network. Although a few local governments, private companies, and media-related nodes are present, they occupy peripheral positions with weak or unidirectional ties. This suggests that national-level knowledge exchange remains institutionally concentrated, with limited integration of local, commercial, or journalistic expertise - a potential blind spot in promoting inclusive or adaptive policy learning.

Other ministries, such as the Federal Ministry for Agriculture and Food (BMEL) and Federal Ministry for Economic Affairs and Climate Action (BMWK), appear mostly as information recipients, indicating that they are important sectoral targets but not perceived as active participants in the dissemination or co-production of knowledge.

Overall, Germany's biodiversity–climate knowledge system displays a functionally coherent but vertically concentrated configuration. A small set of ministries, agencies, and NGOs anchor the structure, scientific institutions supply upstream knowledge, and downstream actors (e.g., local governments, civil society, and sectoral ministries) serve as policy audiences. The network is technically robust and policy-oriented, but opportunities remain to improve horizontal integration, feedback mechanisms, and inclusion of underrepresented knowledge holders.

[5] However, because the sampling strategy in Germany focused primarily on government, civil society, and private sector respondents, we cannot make conclusive claims about the roles of academic and research organizations in receiving information from other organisations.

3.1.4 Improvement of Knowledge Exchange

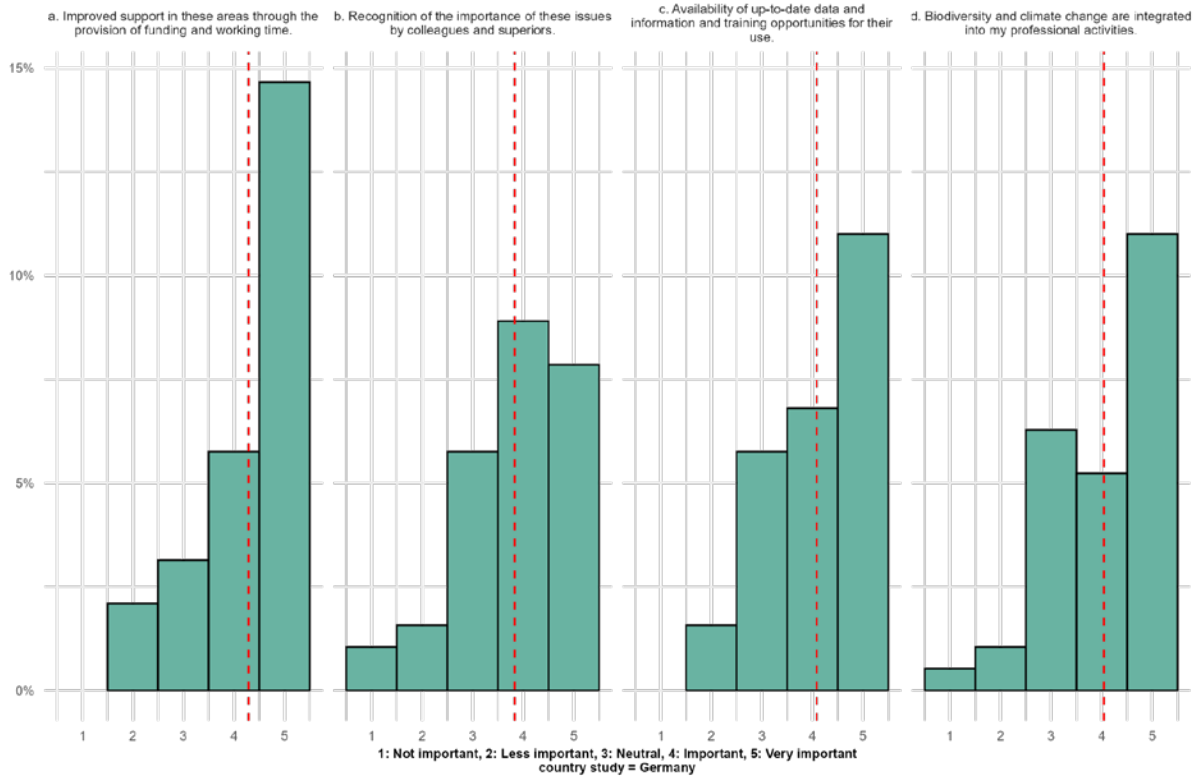

Figure GER-10. Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

This figure displays respondents' levels of agreement (on a 1–5 Likert scale) to four statements related to conditions that support knowledge exchange across biodiversity and climate domains.

"I need support in these areas through the provision of funding and working time.": This item received the highest mean score (4.29), with the majority of responses clustering at level 5. This suggests strong consensus on the need for institutional and resource support as a precondition for engaging in knowledge work.

"I have access to up-to-date data and information and training opportunities for exchange.": This statement was also rated highly (mean: 4.08), with a left-skewed distribution indicating that many respondents feel reasonably well-equipped, though not universally so, in terms of informational infrastructure and capacity-building.

"Biodiversity and climate change are integrated into my professional activities.": With a mean of 4.04, this item reflects a generally positive view of integration at the individual role level, suggesting that for most respondents, the topics are not external add-ons but embedded in their workflows.

"I receive recognition of the importance of these issues by colleagues and supervisors.": This statement had the lowest mean (3.83), with more spread across the scale. While still above neutral, the distribution suggests that relational or cultural forms of support, such as organizational buy-in, are more uneven.

Respondents in Germany express strong agreement with the structural needs required to facilitate knowledge exchange, particularly with respect to dedicated time and funding. This underscores that, even in a relatively well-resourced context, actors perceive knowledge work as an additional burden unless actively supported by institutional frameworks.

The relatively high scores on data access and professional integration reflect the maturity of the German science–policy interface in this domain. Many actors appear to operate within systems where biodiversity–climate issues are already part of the organizational mandate.

However, the lower score on collegial and supervisory recognition may point to a cultural or managerial gap: even when tasks are structurally resourced and integrated, respondents may still face limited symbolic or peer validation. This lack of social acknowledgment could have downstream effects on motivation or prioritization, especially in hierarchical bureaucracies.

Taken together, the results point to a dual challenge: while Germany may be structurally well-positioned to facilitate knowledge exchange, soft relational and organizational culture dimensions remain uneven. This reinforces the need for not only technical capacity-building but also normative and institutional incentives that validate such work internally.

Further, to questions related to effectively integrate information on climate change and biodiversity into decision-making processes, the responses in Germany revealed several bundles of measures at different levels:

Improved access to information: Scientific findings must be made available in comprehensible and well-prepared formats — including concise summaries, which translate findings for practical use in policy decisions), position papers (which express institutional positions on specific issues), and illustrative regional case studies. Access to standardized, easy-to-understand data (e.g. via national and international databases) should be simplified. Additionally, respondents emphasized the need to consolidate knowledge and establish uniform metrics, especially for businesses. Direct contact with scientific experts was also considered essential.

Enhanced exchange between levels and actors: Dialogue between science, politics, expert committees, and practice must be intensified (e.g. interministerial working groups, multi-stakeholder dialogues, and effective interfaces with NGOs and the media).

Political prioritization and structural anchoring: Climate protection and biodiversity must be clearly prioritized on the political agenda. This includes legal frameworks, funding programs, and the provision of human and financial resources – especially at the municipal and regional level. Decisions must be based on expertise and not political setting. A decoupling of politics and economic interests is necessary, along with the internalization of climate and biodiversity costs in the economic system. Biodiversity and climate protection must be pursued as interconnected goals rather than being played off against each other.

Integration with other policy areas: Biodiversity and climate change must be more closely linked with other policy fields and sectors through a holistic approach. Interdependencies and connections with other areas should be communicated more clearly to create pressure for action and foster political and economic self-interest in these issues.

Focus on concrete and local level: Scientific information should always be accompanied by concrete, actionable policy options. The focus must shift more strongly toward implementation and practical relevance, rather than solely on the generation of knowledge. Local projections, visible personal impacts, and concrete regional and sectoral consequences should be made clear to highlight the societal relevance.

Raising awareness and improving public communication: The significance of climate change and biodiversity loss must be made more understandable to both policymakers and the general public. This requires stronger media presence, combating misinformation, clearly prepared content accessible to non-experts, and compelling, positive narratives. Educational efforts, training programs, and public acknowledgment of scientific facts by institutions and associations are essential.

Preferences for Strengthening Cooperation and Information Exchange

Respondents expressed interest in strengthening cooperation with a wide range of organizations across the scientific, policy, civil society, and private sectors. These preferences reflect both the diversity of actors involved in biodiversity–climate knowledge exchange and the need for more direct, accessible, and practice-oriented engagement formats.

Scientific and Policy Institutions: Several respondents emphasized the importance of closer collaboration with established scientific and policy institutions, including RIFS Potsdam, Stiftung Wissenschaft und Politik, UBA, and NEFO. In the policy domain, they identified a desire to work more closely with federal-level ministries and parliamentarians, as well as sub-national agencies responsible for environmental governance.

Civil Society and Citizen Engagement: Civil society organizations were highlighted for their ability to connect national-level discussions with regional and community-level concerns. Respondents viewed these actors as valuable partners in grounding biodiversity and climate information within lived experiences and public advocacy.

Implementation-Oriented Stakeholders: A number of respondents identified the importance of working more closely with implementation-focused actors, such as agricultural advisory services, water management bodies, municipal utilities, and local development authorities. These organizations were seen as crucial intermediaries for translating scientific knowledge into actionable outcomes.

Respondents indicated a preference for practical and interactive formats that support relevance and accessibility: *Policy briefs and position papers* from research institutions were valued for summarizing current political developments in an actionable way. *Informal exchanges and direct communication,* including roundtable discussions and workshops, were frequently mentioned as effective for building mutual understanding. *Online formats*, such as mailing lists, online forums, and virtual events, were also cited as important tools for accessible and continuous information flow.

3.6 Hungary

3.6.1. Information on Respondents

In Hungary in total 41 respondents completed the survey. The most frequently reported role among Hungarian respondents is the provision of technical or professional expertise (~30 respondents), underscoring the prominence of actors involved in supplying evidence-based input into decision processes. This aligns with the overrepresentation of scientific institutions, subnational offices, and agencies in the Hungarian sample. It is, however, also the result that some other groups are not really functional in Hungary (subnational level), or have a short history (like think thanks or multipliers). Around 15 respondents each indicated participation in decision-making and communication or forwarding of recommendations within their organizations. This more even distribution suggests that while many respondents act as knowledge providers, there is also meaningful engagement with internal decision-making processes and the intermediary role of internal communication. For further actor specific distribution see the Appendix.

3.6.2 Network

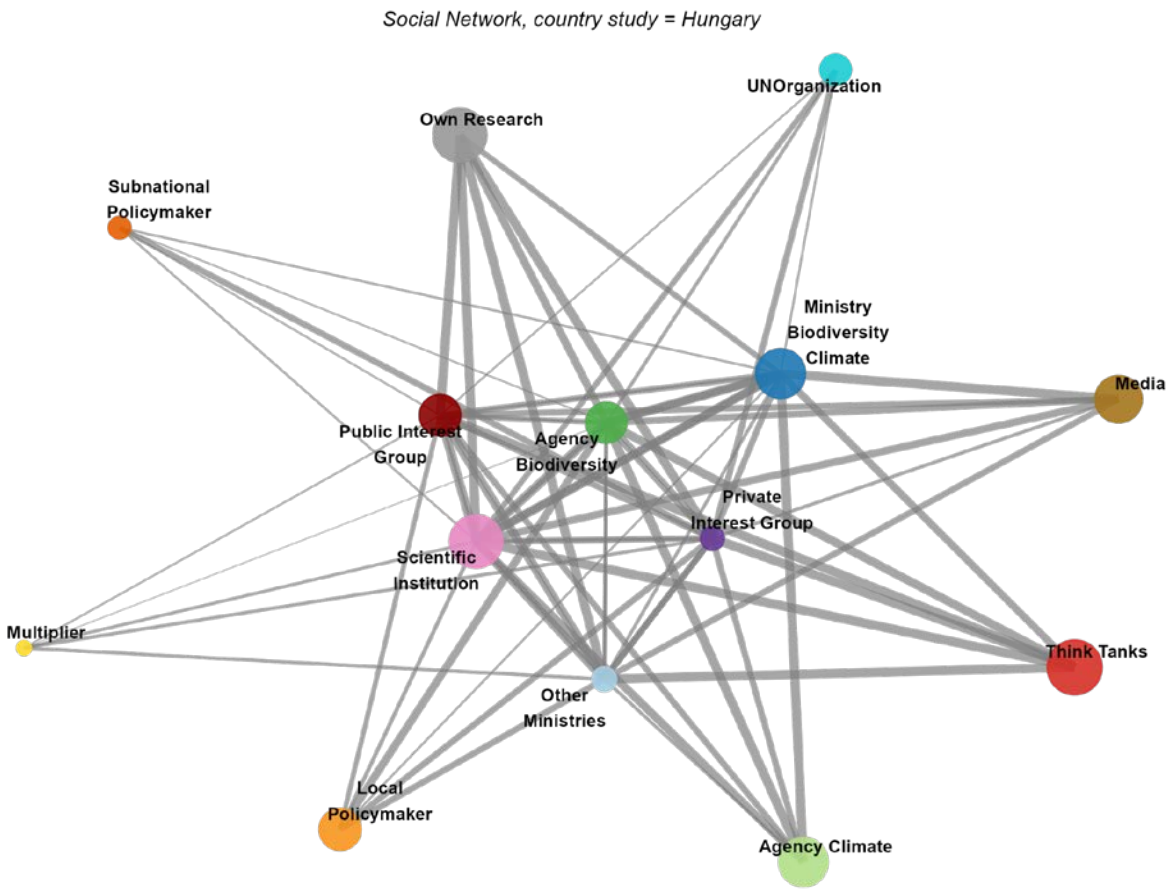

Figure HUN-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Hungary.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	InDegree	OutgoingFlow	Betweenness
PublicInterestGroup	7	6.37	0.0225
ScientificInstitution	7	6.73	0.0305
SubnationalPolicymaker	7	4.12	0.00310
LocalPolicymaker	7	4.24	0
Media	7	6.46	0
OwnResearch	7	5.41	0
AgencyBiodiversity	6	4.73	0.0114
MinistryBiodiversity	6	4.83	0.00333
MinistryClimate	6	3.82	0
UNOrganisation	6	4.51	0
PrivateInterestGroup	5	1.99	0.00532
OtherMinistries	5	1.38	0
ThinkTanks	5	1.87	0
AgencyClimate	4	1.49	0
Multiplier	4	1.78	0
OtherPolicymaker	0	0	0

Table HUN-1.

Metric	Value
Total Nodes	16
Total Edges	89
Number of Isolates	1
In-Degree Centralization	0.096

Table HUN-2.

The SNA map of Hungary reveals a moderately distributed knowledge exchange structure, with a mix of governmental, scientific, and civil society actors recognized as biodiversity–climate information providers. The network comprises 16 actor categories and 89 directed ties, with only one isolate ("OtherPolicymaker") and an in-degree centralization score of 0.096, suggesting a relatively balanced pattern of information provision.

Two actor types, Scientific Institutions and Public Interest Groups, emerge as the most prominent providers in the network. Each is cited by all seven respondent categories (in-degree = 7) and shows high normalized outgoing flows (6.73 and 6.37, respectively). Both also have the highest betweenness centrality values in the network (0.0305 and 0.0225), indicating that they not only distribute information widely but also play modest bridging roles across otherwise disconnected parts of the network.

Other highly cited actors include Media, Subnational Policymakers, and Local Policymakers, all with an in-degree of 7. While Media and Own Research also show strong outgoing flow scores (6.46 and 5.41), Subnational and Local Policymakers record lower values (4.12 and 4.24), suggesting their function is primarily as recipients rather than as major information disseminators. The near-zero or zero betweenness scores for these groups reinforce their peripheral brokerage roles.

Agency for Biodiversity and the Ministry of Biodiversity occupy mid-level positions, with in-degrees of 6 and moderate flow scores (4.73 and 4.83). While both are recognized providers, their lower betweenness scores suggest that they do not operate as key connectors in the network. In contrast, AgencyClimate ranks low on all metrics (in-degree = 4; flow = 1.49; betweenness = 0), indicating limited visibility as an information source in the eyes of respondents.

Peripheral actors include Private Interest Groups, Other Ministries, Think Tanks, and Multipliers, all of which have low in-degrees (4–5), low outgoing flows (1.38–1.99), and no measurable betweenness centrality. While these actors are present in the network, they are not perceived as major sources of biodiversity–climate knowledge within the current exchange structure. The lone isolate, OtherPolicymaker, was not named as a provider by any respondent, highlighting a potential gap in institutional visibility or relevance. At the graph level, the modest centralization score supports the interpretation of a distributed knowledge landscape, with several actors contributing to provision rather than a single dominant hub.

In sum, Hungary's network reflects a structure where non-governmental actors, particularly scientific bodies and public advocacy groups, play central roles in both visibility and connectivity. Government agencies and ministries are active but less structurally central. The presence of low-visibility providers, especially in the private sector and intermediary domains, points to areas where knowledge dissemination could be expanded or better supported.

3.6.3 Information Flows

3.6.3.1 Information Flow by Format

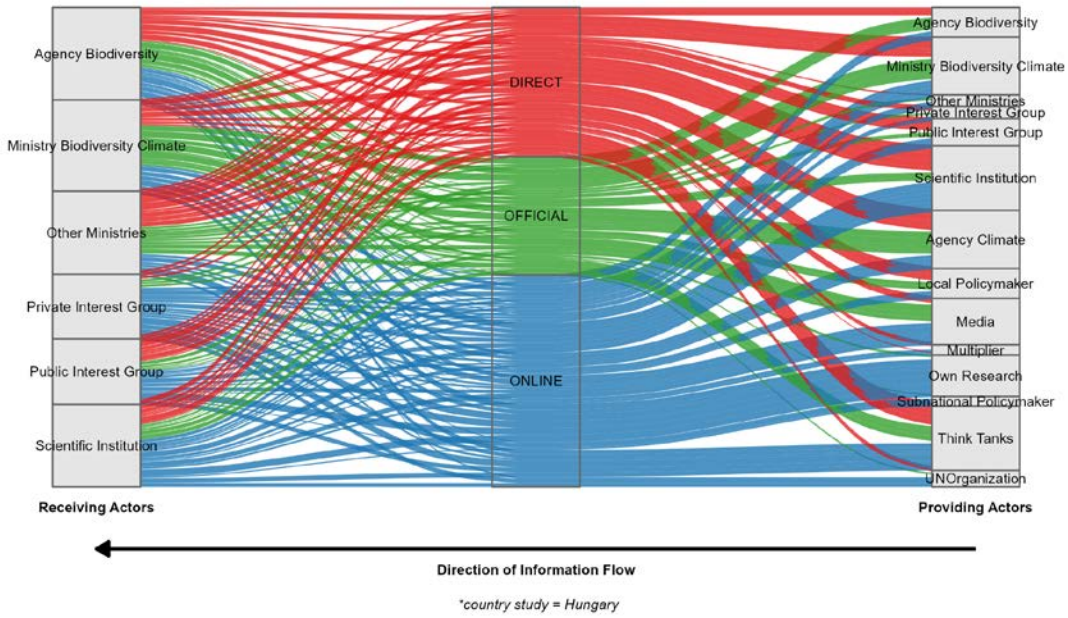

Figure HUN-2. Format-specific Sankey diagram showing how information from providers reaches receivers in Hungary, segmented into three formats: Digital and online media (websites, social media, newsletters); Official and formal documents (reports, summary for decision-makers, IPCC reports, IPBES reports, information sheets) and Direct and indirect communication (emails, phone calls, expert advice, workshops, conferences)

The Sankey diagram visualizes the flow of biodiversity and climate information in Hungary, segmented by three communication formats—Direct (red), Official (green), and Online (blue)—from various provider categories (left) to receiver categories (right). Online formats dominate the overall distribution. These are heavily used by UN Organizations, Scientific Institutions, and Public Interest Groups, and are primarily directed toward other Scientific Institutions, Subnational Policymakers, and Ministries. This suggests a broad reliance on digital dissemination, particularly for cross-sector and transnational communication. Official formats are moderately used, particularly by Ministries, Agencies, and Private Interest Groups. The most frequent recipients of official communication are Scientific Institutions, Other Policymakers, and Public Interest Groups, pointing to a structured, institutionally mediated form of knowledge exchange. Direct formats are visibly used by Ministries, Subnational Policymakers, Agencies, and notably Think

Tanks. They tend to direct this mode of exchange to other ministries, subnational actors, and scientific institutions, indicating reliance on in-person or synchronous formats among governmental and knowledge-producing bodies. The Ministry of Biodiversity and Climate emerges as both a major provider and recipient across all three formats, particularly in official and online flows, reflecting its dual role in coordination and implementation. Multipliers, Media, and Own Research play more peripheral roles in total volume but still contribute through online dissemination, especially toward Subnational Policymakers and Public Interest Groups. Public and Private Interest Groups are engaged in both sending and receiving, especially via online and official formats, though their direct exchange is more limited in comparison to ministries or scientific institutions.

The knowledge exchange landscape in Hungary is highly digital, with online formats comprising the largest share of interactions. This underscores a systemic reliance on internet-based communication, potentially facilitating wide accessibility and inclusiveness. However, it may also limit depth of engagement or contextual specificity, especially where digital infrastructure or trust-building are critical. Scientific Institutions and Public Interest Groups are central in this digital web, both as senders and recipients, indicating strong participation from civil society and research communities. This suggests potential for evidence-informed pluralism, but may also point to overburdening of these actors as knowledge brokers without corresponding authority.

Ministries and agencies leverage a more balanced mix of formats, suggesting their role in maintaining formal policy interfaces. Their substantial use of official communication reflects procedural obligations but also potential limitations in agility or dialogic exchange. Subnational actors, while present as both providers and recipients, rely predominantly on direct formats, indicating a preference or necessity for localized, interpersonal channels. However, this reliance may result in information asymmetries if not complemented by online or official flows. Think Tanks, despite their normative role as intermediaries, appear less central than expected in Colombia's network, particularly in official exchanges. This may indicate underutilized capacity in translating scientific knowledge for policy uptake. Overall, the Hungary case reveals a multi-format communication system, with clear horizontal engagement across actor types but uneven vertical integration. Despite the availability of official formats, the dominant use of online channels may pose challenges in achieving context-responsive and trust-based policy action unless paired with complementary formats.

3.6.3.2 Receiver-Specific Information Flow

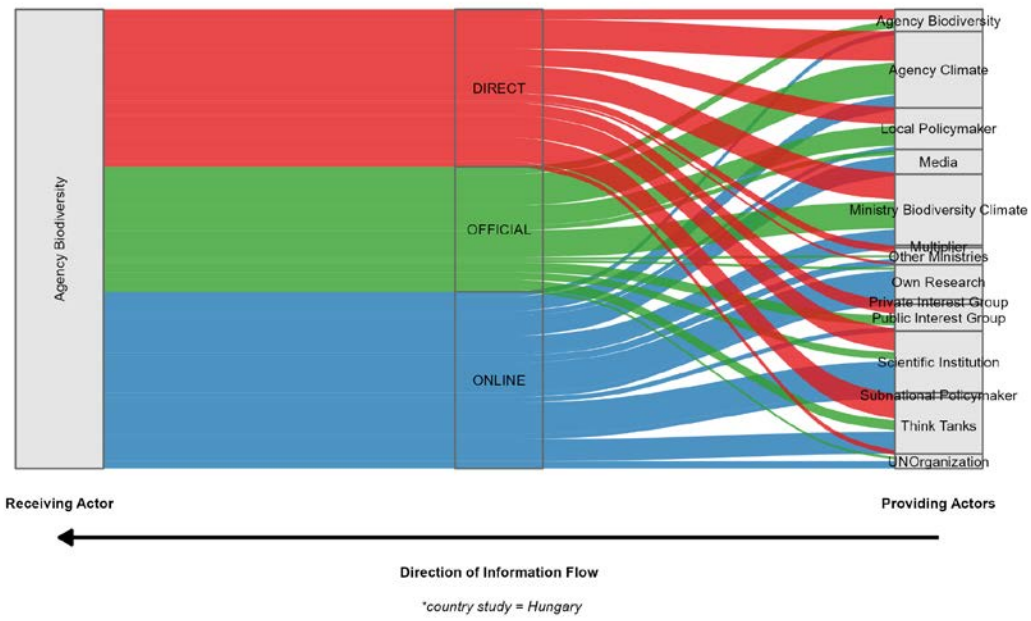

Figure HUN-3. Receiver-Specific (Agency responsible for Biodiversity) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

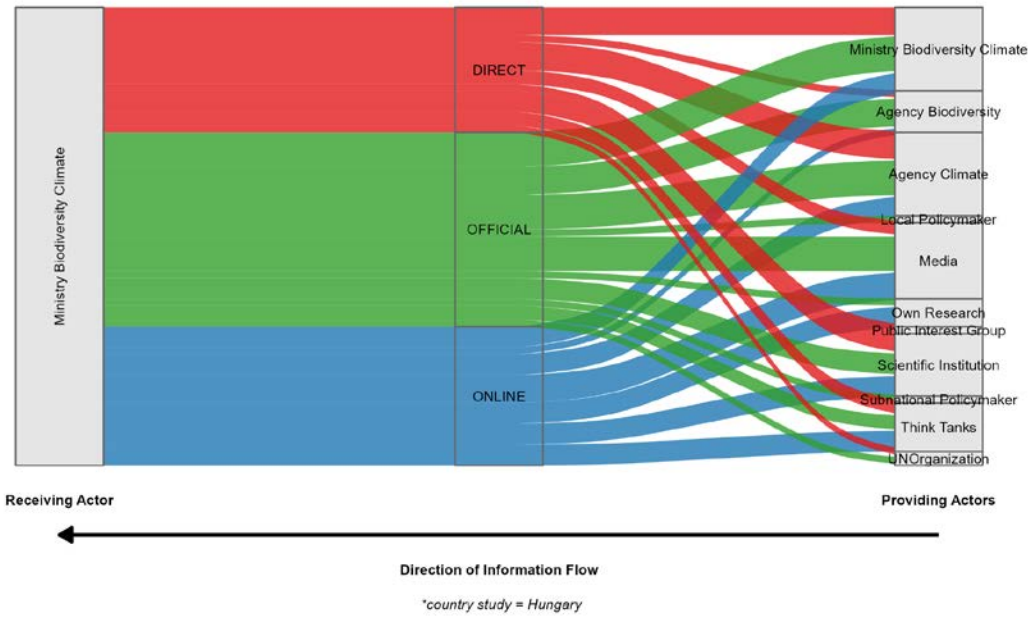

Figure HUN-4. Receiver-Specific (Ministry responsible for Biodiversity and Climate) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

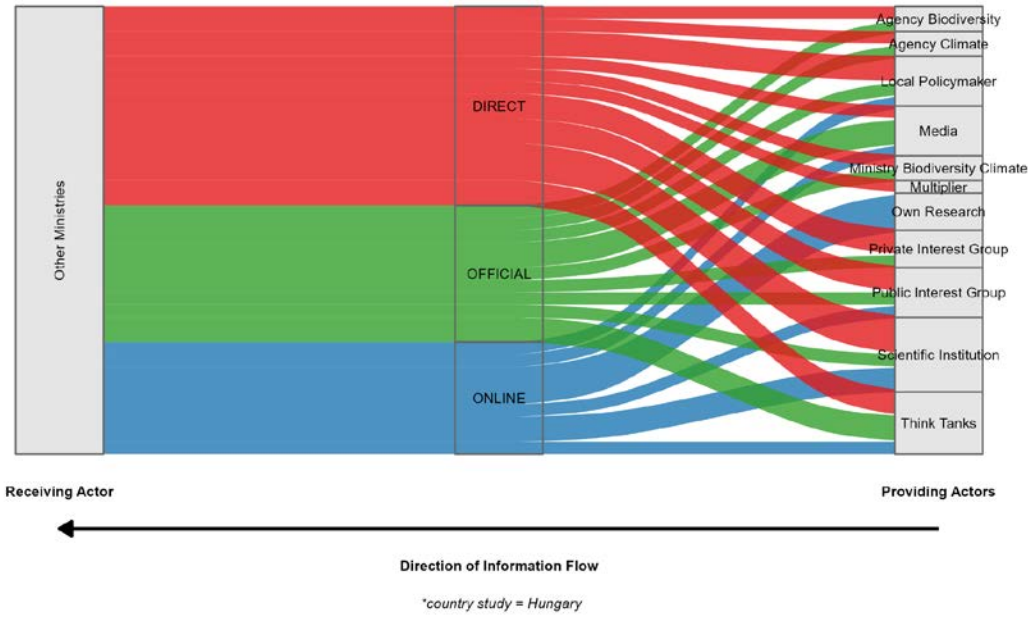

Figure HUN-5. Receiver-Specific (Other Ministries) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

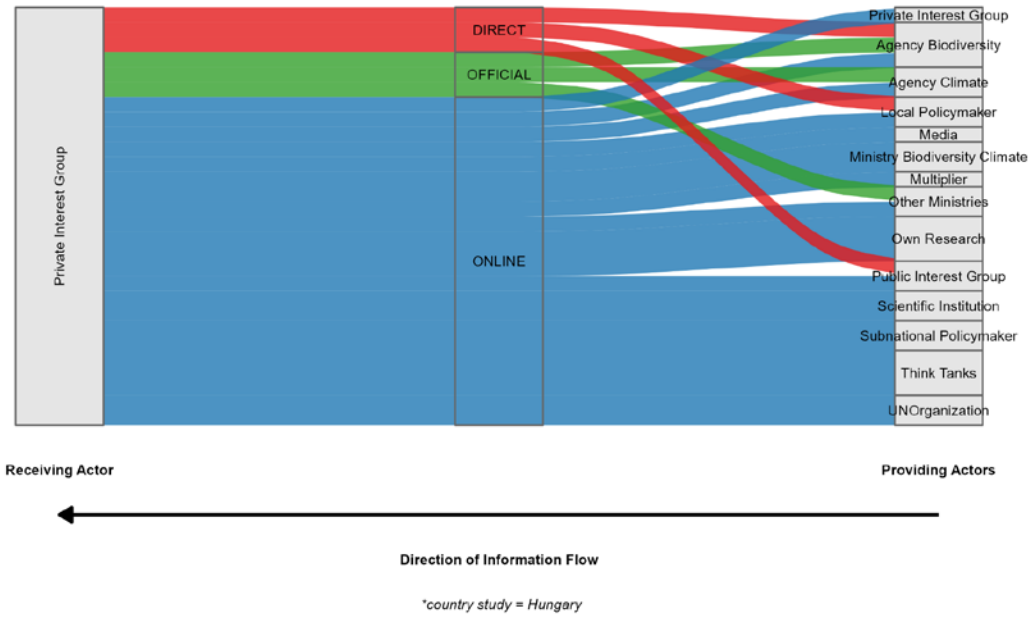

Figure HUN-6. Receiver-Specific (Private Interest Group) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

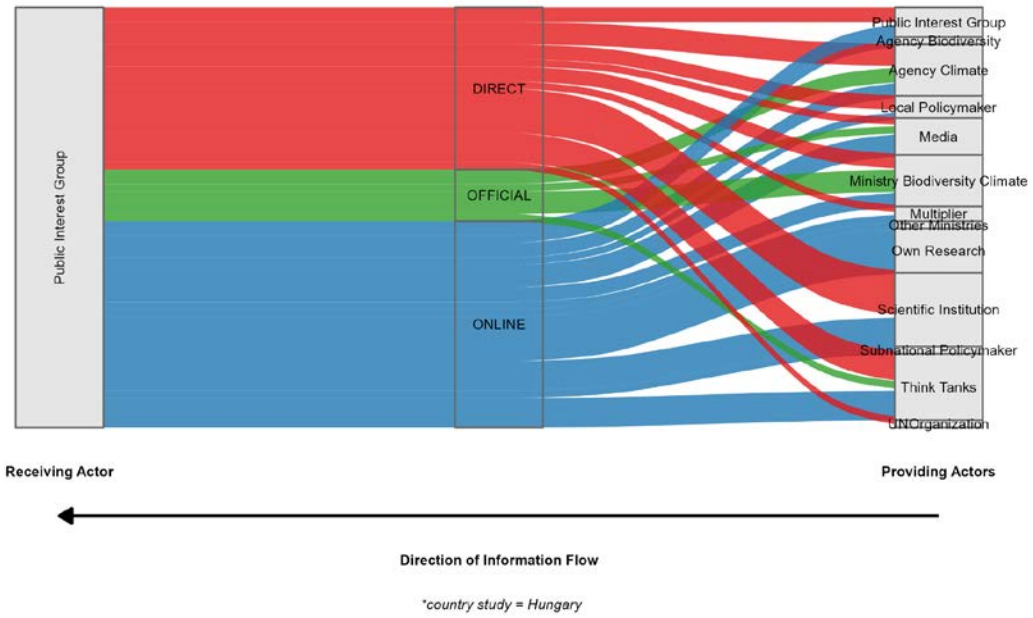

Figure HUN-7. Receiver-Specific (Public Interest Group) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

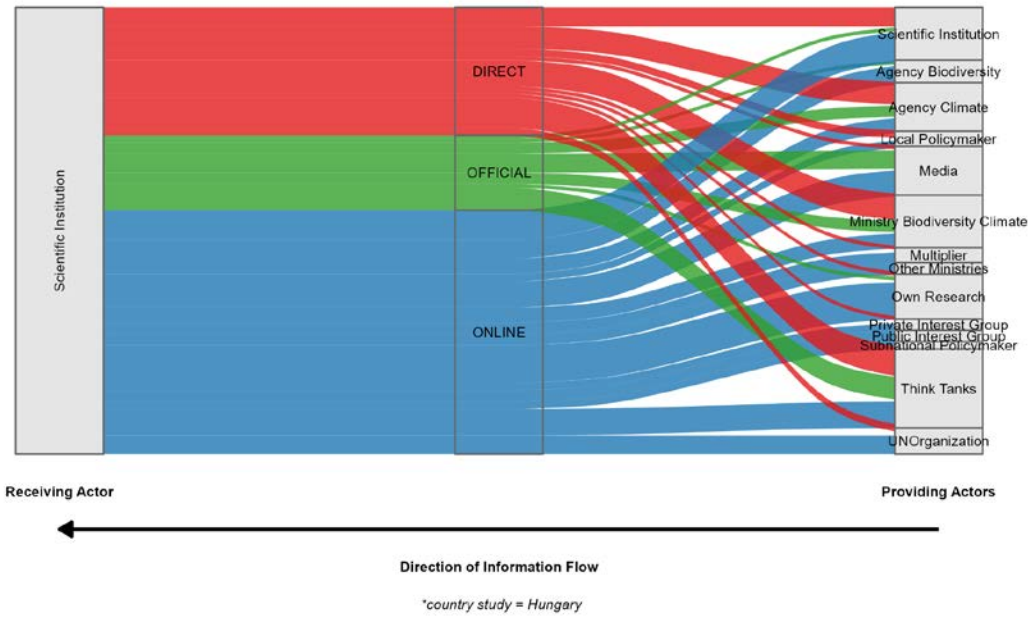

Figure HUN-8. Receiver-Specific (Scientific Institution) Information Flow in Hungary, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities

Ministry of Climate: Most frequent format: Online and official formats are equally dominant; direct exchange is less frequent. Key recipients: Ministry of Biodiversity, Subnational Policymakers, and Public Interest Groups. The Ministry of Climate plays a central dissemination role through institutional formats, especially in cascading information to other public bodies and implementing agencies. The reliance on official and online mechanisms signals an emphasis on formal communication, possibly for legitimacy and traceability.
Ministry of Biodiversity: Most frequent format: A balanced mix of online, official, and direct channels. Key recipients: Scientific Institutions, Public Interest Groups, and Agencies. The Ministry of Biodiversity uses a more diversified communication strategy, suggesting responsiveness to both institutional partners and non-state actors. Their engagement with scientific actors implies an interface role in translating research to governance.
Subnational Policymaker: Most frequent format: Strong emphasis on direct formats, followed by official. Key recipients: Ministries, Agencies, and Public Interest Groups. These actors show stronger tendencies toward relational, direct communication. The limited online exchange reflects possible infrastructure gaps or preferences for more tangible modes of interaction.

Local Policymaker: Most frequent format: Online formats dominate, followed by direct. Key recipients: Scientific Institutions, Ministries, and Agencies. Local-level actors demonstrate strong outward engagement through digital channels. Their recipients are largely upward (to national bodies) or horizontal (to implementers), indicating efforts to scale or validate local inputs.

Agency for Biodiversity: Most frequent format: Balanced mix of direct, official, and online. Key recipients: Other Ministries, Policymakers, and Public Interest Groups. The agency adopts a strategic mix of formats for outreach. This spread suggests that it serves both as a technical actor and a political liaison.

Agency for Climate: Most frequent format: Online and official dominate. Key recipients: Agencies, Public Interest Groups, Scientific Institutions. Although fewer respondents identified with this group, the

communication pattern resembles other public authorities with emphasis on structured dissemination, likely reflecting internal mandates or data-dependent workflows.

II. Scientific/ Research Actors and Intermediaries

Scientific institutions in Hungary serve as major knowledge providers across all three formats—direct, official, and online—with a relatively balanced distribution. They most frequently provide information to public authorities (Ministry of Biodiversity, Ministry of Climate, and agencies), as well as to other research institutions and civil society groups. Official formats are prominent in interactions with ministries and agencies, while online channels appear more common in exchanges with civil society and international actors. Main recipients: Ministry of Biodiversity, Agency for Biodiversity, and other scientific institutions.; Dominant formats: Official and online. This distribution underscores the role of scientific institutions as central, formalized contributors to national knowledge infrastructures while also supporting more open, trans-sectoral information flows through digital channels.

Multipliers (e.g. training/extension services) play a less central but still important role in Hungary's information ecosystem. They rely primarily on direct communication to convey knowledge, with some use of official formats and relatively limited online communication. Main recipients: Public authorities (Agency of Biodiversity, Other Policymakers) and scientific institutions; Dominant format: Direct. Multipliers' preference for interpersonal channels is consistent with their bridging function—often situated between abstract knowledge production and applied implementation.

The media landscape in Hungary is dominated by online dissemination. Almost all information flows from media actors are channeled through online formats, targeting a broad range of recipients, including ministries, agencies, scientific institutions, and civil society. Main recipients: Scientific institutions, public interest groups, and political actors.; Dominant format: Overwhelmingly online (unsurprising). This reflects the broadcast and digital-first nature of media engagement, which, while expansive, may lack the tailoring or feedback loops needed for embedded policy uptake.

III. Interest and Advocacy Groups

Public Interest Groups in Hungary emerge as notable providers of biodiversity and climate-related knowledge, distributing information broadly across political and scientific actors. The preferred modes of transmission are direct communication and online formats, both of which appear equally dominant in volume. Official formats, by contrast, are noticeably less used in their communication strategies.

Their information reaches a wide spectrum of recipients, including ministries (both biodiversity/climate and others), agencies, scientific institutions, and other public interest groups, indicating strong horizontal and vertical outreach. Notably, substantial information also flows to scientific institutions, pointing toward a bidirectional or at least interactive relationship between civil society and research entities. These findings suggest that Hungarian civil society organizations are not only active in advocacy but also play a central role in the *knowledge brokering ecosystem*. The predominance of informal (direct) and virtual (online) communication methods suggests flexibility and responsiveness, allowing them to adapt content for different audiences. However, the limited use of formal (official) formats could signal challenges in institutionalizing their inputs in formal governance processes—potentially limiting their influence on legally binding decisions or policy frameworks. Their engagement with scientific institutions also hints at the co-creation or mutual validation of knowledge, especially relevant in highly politicized or contested domains like biodiversity and climate governance.

Private Interest Groups (e.g., business associations, sectoral lobby groups) provide information almost exclusively via direct and online formats, with minimal use of official formats. Their communication appears strongly targeted toward scientific institutions, ministries, and public interest groups, with lesser interaction noted with subnational or local policymakers. This format preference and recipient focus suggest that private actors in Hungary engage primarily through strategic, informal dialogue—likely aiming to influence early policy development or shape stakeholder consensus outside formalized state channels. Their strong information provision to scientific institutions may reflect interest in evidence-based legitimacy

or joint assessments (e.g., on sustainability or innovation). However, the lack of outreach to subnational governance bodies could indicate a centralization of their influence or limited engagement with place-based implementation concerns.

IV. Think Tanks and Capacity Building Organisations

Formats: Think Tanks primarily used Direct and Online formats, with almost equal proportions. Official formats were not used at all. Key recipients: The majority of information is directed to Subnational Policymakers, followed by Scientific Institutions, Public Interest Groups, and Private Interest Groups. Minimal flows are directed to Other Ministries or Agencies. The complete absence of official channels indicates that Think Tanks are operating primarily through informal or non-institutionalized mechanisms such as workshops, white papers, consultations, rather than formal reports or government briefs. Their simultaneous outreach to scientific and civil society actors reinforces their bridging position, but the lack of ties to ministries limits their potential influence on formal policy making.

For UN Organisations: Formats: UN bodies relied heavily on Online and Official communication. Direct engagement is visible but less pronounced. Key recipients: They provide information to Ministries of Biodiversity/Climate, Agencies, Scientific Institutions, and Interest Groups, with limited flow to Subnational Policymakers and Other Policymakers. Recipients are predominantly national authorities and institutional actors, suggesting alignment with formal state-led implementation structures. Limited engagement with subnational or more peripheral actors may constrain the reach and contextualization of global knowledge at local levels, despite Hungary's centralized governance model. The dominance of Online and Official formats reflects the structured, standardized dissemination typical of intergovernmental organizations, such as distributing IPBES/IPCC outputs or technical guidance.

3.6.3.3 Links between Organizations

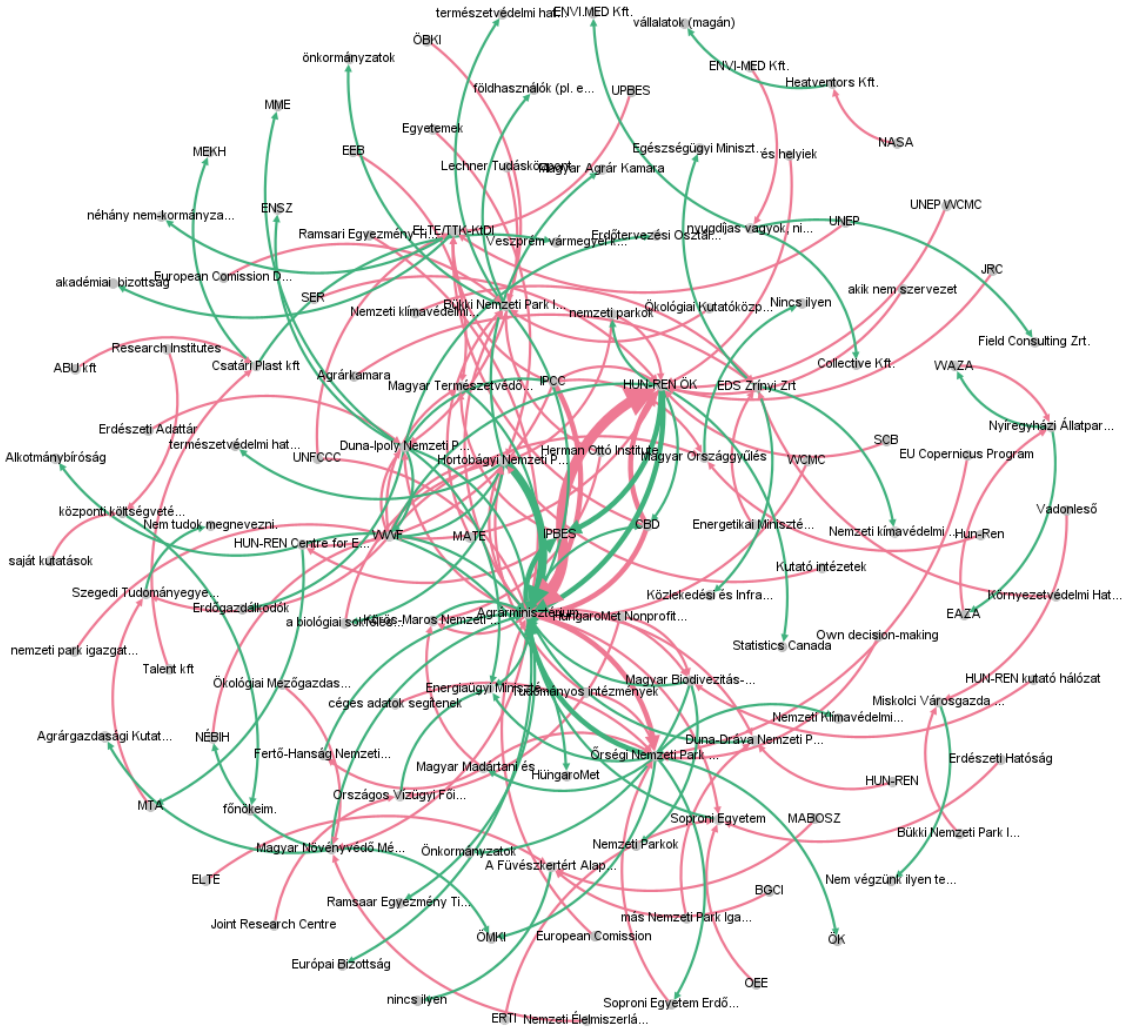

Figure HUN-9: Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.

The organization-level SNA map for Hungary depicts a moderately dense and multi-actor knowledge exchange system structured around a small number of key hubs, a second tier of civil society and scientific intermediaries, and a broader periphery of recipients. While some public institutions receive high volumes of information, active redistribution is concentrated in a limited number of hybrid actors that serve as informal brokers across governance levels.

The Ministry of Agriculture (AM) and the Ministry of Interior (BM) are central actors in terms of incoming information flows. Their position in the network - as dominant recipients but with few outgoing ties - suggests a system in which political decision-makers are key targets of biodiversity and climate knowledge but do not actively redistribute or co-produce this information within the broader network. The Ministry of Energy, Energy Efficiency and Renewable Energy Center, and other line ministries appear similarly positioned, indicating a unidirectional relationship with scientific and civil society actors.

In contrast, knowledge provision is heavily concentrated in environmental research institutions and NGOs. WWF Hungary, BirdLife Hungary (MME), and IPBES Hungary DK emerge as key intermediaries with visible bidirectional links. These organizations receive inputs from both domestic research institutions and international platforms and actively forward knowledge to ministries, municipalities, and protected area authorities. This reflects a system in which civil society fills a bridging role between technical expertise and state institutions.

Scientific institutions such as MTA, ELTE, and the Centre for Ecological Research (ÖK) are among the most visible providers of information, forwarding knowledge to both ministries and civil society actors. However, these institutions are largely absent from the receiving side of the network, reinforcing their role as upstream knowledge producers with limited institutionalized engagement in feedback loops or policy adaptation processes.

Notably, the Duna-Ipoly National Park Directorate, Hungarian Biodiversity Research Coordination Group, and National Park system appear in both incoming and outgoing flows, highlighting the role of protected area authorities not only as recipients of scientific and policy information but also as contributors to knowledge redistribution. This is uncommon in many national systems and points to a growing role for park directorates in brokering context-specific environmental knowledge.

A range of international organizations and platforms, e.g., IPBES, CBD, UNFCCC, the European Commission, and JRC are present primarily as recipients, reflecting Hungary's international reporting obligations rather than bilateral knowledge exchange. Their role in this network is largely symbolic or compliance-driven, rather than embedded in national feedback structures.

The private sector, subnational governments, and professional associations are relatively underrepresented in both outgoing and incoming flows. A few consultancies and environmental businesses (e.g. VA2A, Field Consulting Zrt.) appear at the margins, indicating potential but underutilized links to practice-based knowledge systems. Similarly, municipalities and local authorities are sparsely connected, revealing a structural gap in vertical information integration.

Overall, Hungary's SNA map reveals a functionally layered knowledge ecosystem. While civil society and scientific actors play strong roles in information provision, and a few intermediaries redistribute knowledge across levels, government ministries primarily absorb information without substantial outward engagement. The structure indicates a dependency on intermediaries, especially NGOs and hybrid platforms, for policy-relevant knowledge translation. Strengthening bidirectional links with ministries and fostering more inclusive feedback channels across levels of governance could enhance the integration, responsiveness, and legitimacy of Hungary's science-policy interface for biodiversity and climate. The diversity of actors mentioned and the presence of multiple visible connections, however, signal an active ecosystem, even if not fully integrated[6].

[6] *As with other countries, the Hungary survey focused primarily on public authorities, scientific and civil society organizations, and selected international actors. Academic institutions and media actors may be underrepresented in the diagram due to the structure of the sampling frame and should not be interpreted as lacking influence or engagement.*

3.6.4 Facilitation and Improvement of Knowledge Exchange

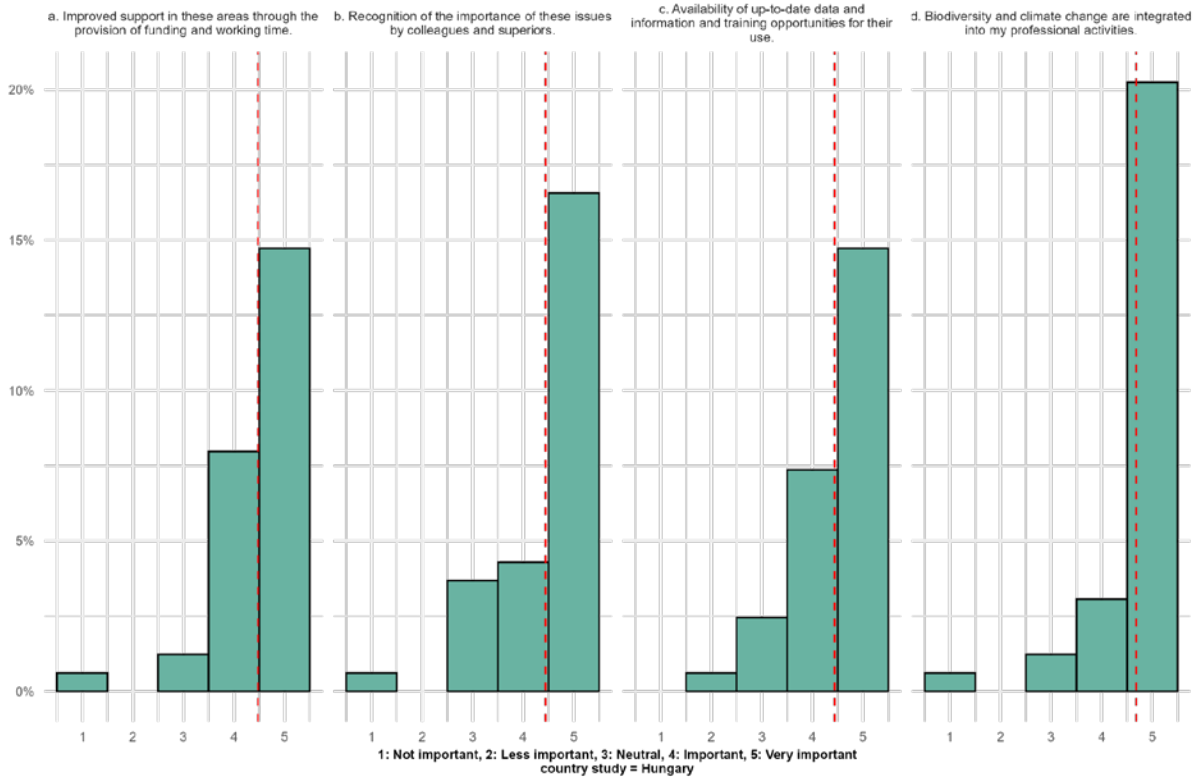

Figure HUN-10. Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

The responses from Hungary show consistently high levels of agreement across all four knowledge exchange statements, indicating an overall supportive environment for integrating biodiversity and climate information into professional work. Respondents most strongly agreed with the statement that *biodiversity and climate change are integrated into their professional activities*, with a mean score of 4.68. This suggests a high degree of normative alignment, in which climate and biodiversity concerns are perceived as integral to day-to-day roles, rather than marginal or secondary concerns.

Similarly, the perceived availability of up-to-date information and relevant training opportunities received strong endorsement, with a mean of 4.44. This reflects positively on Hungary's institutional knowledge infrastructure, suggesting that many respondents feel equipped to access timely scientific or policy-relevant materials and enhance their capacities through formal or informal training.

Respondents also expressed high agreement (mean 4.47) regarding the need for additional support, particularly through funding and allocated working time. This indicates that while knowledge is available and integrated, there remain structural barriers—particularly resource-based—that could constrain sustained or deepened engagement in knowledge-related tasks. High demand for dedicated support reflects a recognition that meaningful science-policy engagement requires institutional investments beyond individual effort.

The lowest score, though still high, related to *recognition by colleagues and supervisors* (mean 4.44). This suggests that while there is substantial normative and technical capacity for engaging with biodiversity-climate issues, social and organizational incentives may be uneven. Professional recognition may still lag behind institutional expectations, particularly in settings where such engagement is viewed as auxiliary to core duties.

Overall, the Hungarian responses portray a strongly positive landscape for knowledge engagement, with high internalization of biodiversity and climate concerns, good access to relevant information, and demand for more formal support. However, the slightly lower agreement on collegial and supervisory recognition hints at possible gaps in institutional reward structures, where individuals may be personally committed, but lack full organizational reinforcement. Strengthening horizontal and vertical acknowledgement mechanisms, within ministries, agencies, and research institutions, could further stabilize and incentivize knowledge co-production in the Hungarian context.

Preferences for Strengthening Cooperation and Information Exchange

Respondents emphasized the critical role of education and communication in raising awareness and strengthening societal engagement with biodiversity and climate change. A recurring recommendation was to integrate environmental issues into early education curricula, ensuring that foundational knowledge is built during childhood and subsequently expanded through secondary education and professional training. Several noted that youth engagement must be reinvigorated, particularly in light of the perceived failure of initiatives like the Fridays for Future movement in Hungary, which lacked sustained political impact.

To shift societal attitudes, respondents called for the widespread display of ecological footprint information on all consumer products, combined with a stronger and more sustained media presence. Suggestions included increasing the visibility of scientific content across mainstream media, launching public awareness campaigns, hosting free and accessible workshops, and investing in government-supported online communication platforms. Reliable, up-to-date data and analysis should be made readily available to the public, with several respondents stressing the need for transparency from environmental authorities, including water and forestry directorates.

There was consensus on the need for the full and free availability of relevant environmental information as a public good. Respondents advocated for targeted support for civil society organizations (CSOs), including the public financing of lobbying activities, which were viewed as essential for balancing dominant policy narratives. At the same time, communication strategies must be fine-tuned to effectively engage the broader public in understanding the urgency and relevance of biodiversity–climate challenges.

Critically, many emphasized that research institutions and experts must be recognized and taken seriously within public discourse and policy processes. Respondents proposed the creation of dedicated forums bringing together policymakers, researchers, land managers, and CSOs to foster more horizontal collaboration. Institutions like the Hungarian Academy of Sciences (MTA) were seen as key actors in enabling interdisciplinary cooperation and breaking down silos between science and policy.

Looking ahead, respondents envisioned the need for a political paradigm shift, both nationally and internationally, that would place environmental issues at the core of governance. This would require not only the training of decision-makers but also institutional reforms, including the establishment of an independent ministry for the environment, the introduction of legal mandates, among other more radical mechanisms.

Respondents further indicated they would like to increase the interaction with Scientific and Policy Institutions, as well as Civil Society. It was highlighted that there is a need for more interaction between ecological, climate and health centres. MTA should foster horizontal interactions, such as inter- and multidisciplinary cooperations. There should be an intensified IPBES cooperation with an employee specifically dealing with these tasks. Respondents affiliated to national parks emphasized that they wished to intensify cooperation with university, research institutes, soil and water directorate and forestry authorities. Regarding the format, political authorities, such as the local governments and the ministry of agriculture indicated their preference for direct (online) communication. The HUN-REN research network aligned with that view. Other preferred formats for information exchange included: in person consultation, newsletters, social media and workshops.

3.7 Spain

3.7.1 Information on Respondents

In Spain in total 19 respondents completed the survey. In Spain the most common contribution is forwarding information (approx. 14 respondents), followed by technical expertise (approx. 12), and decision-making (approx. 9). This reflects a sample skewed toward intermediaries and technical actors, with fewer individuals occupying formal decision-making roles. For further actor specific distribution see the Appendix.

Note on institutional structure: In Spain, both climate and biodiversity policy are governed within the same institutional framework, the Ministry for the Ecological Transition and the Demographic Challenge (MITECO). Unlike some other countries in the sample, Spain does not have separate national agencies for biodiversity or climate. Instead, MITECO contains specialized departments dedicated to different environmental domains, including climate change, biodiversity, and water governance. For this reason, references in the SNA diagrams and Sankey figures to "Ministry of Climate" and "Ministry of Biodiversity" in the Spanish case should be interpreted as referring to the relevant departments within MITECO, rather than separate ministries or agencies.

3.7.2 Network

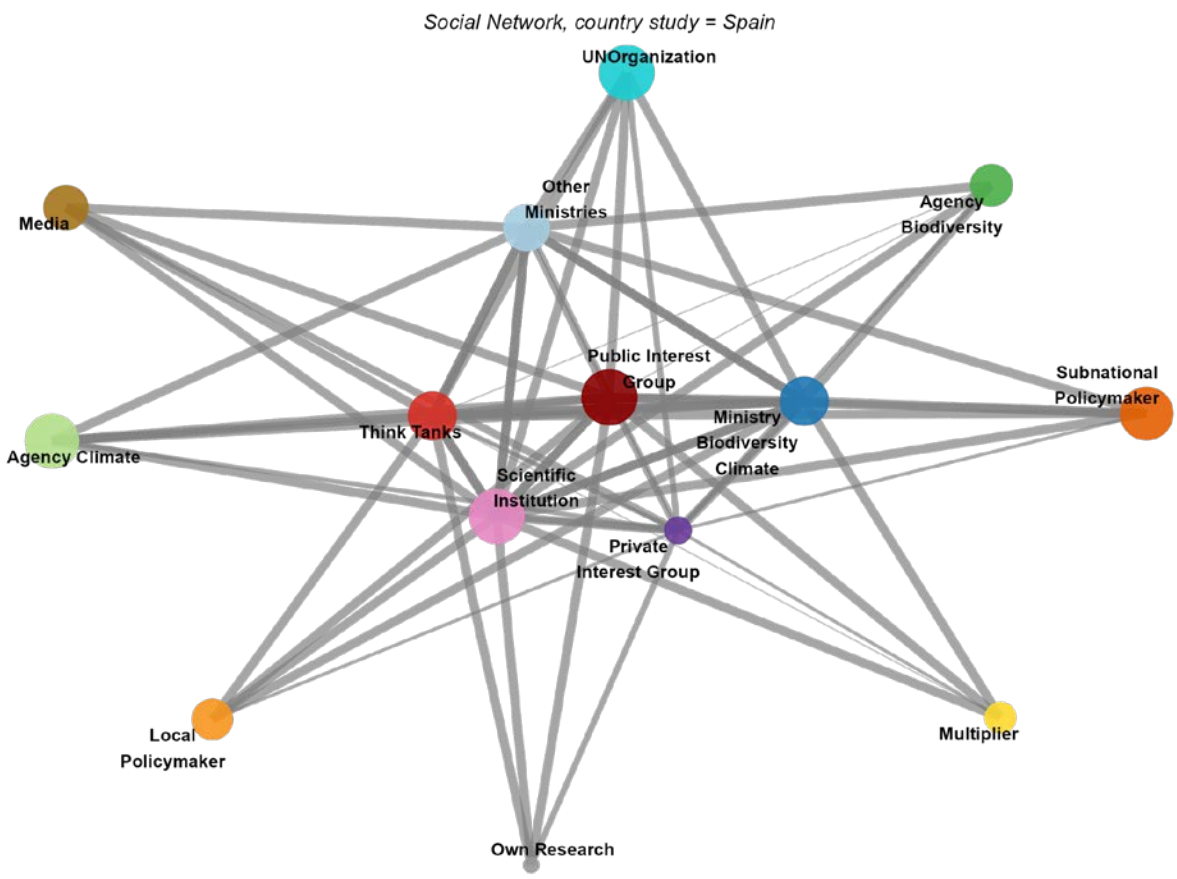

Figure ESP-1. Social network map showing information flows between organization types within the biodiversity–climate knowledge system in Spain.

In terms of how to interpret network metrics for our purposes: In-degree tells us how many actor groups recognize someone as an information provider. Outgoing flow tells us how much information provision is attributed to them overall (weighted and normalized). Betweenness centrality captures which actor types

serve as bridges or intermediaries in the network, facilitating information flow between otherwise unconnected actor groups.

Node	InDegree	OutgoingFlow	Betweenness
MinistryBiodiversityClimate	6	5.23	0.00481
OtherMinistries	6	5.05	0.00128
PublicInterestGroup	6	5.91	0.00983
ScientificInstitution	6	5.82	0.00983
ThinkTanks	6	5.23	0.00983
AgencyBiodiversity	6	4.73	0
AgencyClimate	6	5.73	0
SubnationalPolicymaker	6	5.64	0
UNOrganization	6	5.82	0
PrivateInterestGroup	5	4.00	0.00288
LocalPolicymaker	5	4.64	0
Multiplier	5	4.14	0
Media	5	4.91	0
OwnResearch	4	3.82	0

Table ESP-1.

Metric	Value
Total Nodes	14
Total Edges	78
Number of Isolates	0
In-Degree Centralization	0.033

Table ESP-2.

The SNA map for Spain reveals a relatively decentralized and multi-actor knowledge exchange system for biodiversity–climate information. The network consists of 14 actor categories and 78 directed edges. All nodes have non-zero in-degree, meaning no actor is completely disconnected from information flows. The in-degree centralization score of 0.033 confirms a highly balanced structure, with no single actor dominating provision.

Nine actor types reach the highest observed in-degree score (6), indicating that they were named by all or nearly all respondent groups as sources of information. This includes a combination of government ministries, agencies, scientific institutions, civil society organizations, and subnational actors. These findings suggest that many types of institutions are seen as legitimate providers of biodiversity–climate knowledge in Spain.

Among the most prominent providers are Scientific Institutions and Public Interest Groups, which combine high in-degree (6), high outgoing flow (5.82 and 5.91), and the highest betweenness centrality values in the network (both 0.00983). These actors appear not only as widely recognized sources of information but also as potential bridges that connect different parts of the network, enhancing cross-sectoral knowledge circulation. Their dual role as providers and connectors reflects their importance in the national science–policy interface.

Think Tanks also show high in-degree (6) and similar betweenness centrality (0.00983), suggesting they play a significant intermediary role. Their slightly lower normalized outgoing flow (5.23) indicates they may be less prolific than scientific or civil society actors in information dissemination, but still maintain strong structural relevance by linking diverse actor groups.

Governmental actors such as the Ministry of Biodiversity and Climate (flow = 5.23, betweenness = 0.00481) and Other Ministries (flow = 5.05, betweenness = 0.00128) are frequently cited but exhibit lower betweenness. This implies that they are recognized providers, but are less active in linking across network segments. These ministries may function more as institutional sources of formal information rather than dynamic intermediaries or brokers.

Other actors such as AgencyClimate, AgencyBiodiversity, and Subnational Policymakers match the top in-degree score (6) and have moderately high flows (4.73–5.73), but exhibit zero betweenness. This suggests that while they are visible and relevant, they do not serve integrative roles in the structure of information exchange.

Actors like Private Interest Groups, Media, Multipliers, and Own Research appear more peripheral. Private Interest Groups, while moderately cited (in-degree = 5) and with some bridging capacity (betweenness = 0.00288), have a relatively low flow value (4.0). Own Research, with the lowest in-degree (4) and the lowest outgoing flow (3.82), sits at the edge of the network in terms of perceived contribution. No isolates were identified in the Spanish network, which, along with the flat in-degree distribution, reinforces the interpretation of a collaborative and inclusive knowledge landscape. However, the low overall betweenness values across most actor types indicate that few actors perform strong bridging functions, and much of the knowledge provision may occur in parallel rather than through integrated or co-produced channels.

In sum, the Spanish SNA network demonstrates a pluralistic structure in which scientific, civil society, and government actors all contribute to knowledge dissemination. Scientific Institutions and Public Interest Groups play prominent structural roles, while ministries are consistently visible but less integrative. Peripheral actors remain engaged but have lower influence on information connectivity. These findings support the view of Spain's biodiversity–climate science–policy interface as broad-based and decentralized, though further opportunities may exist to strengthen brokerage and coordination across actor groups.

3.7.3 Information Flows

3.7.3.1 Information Flow by Format

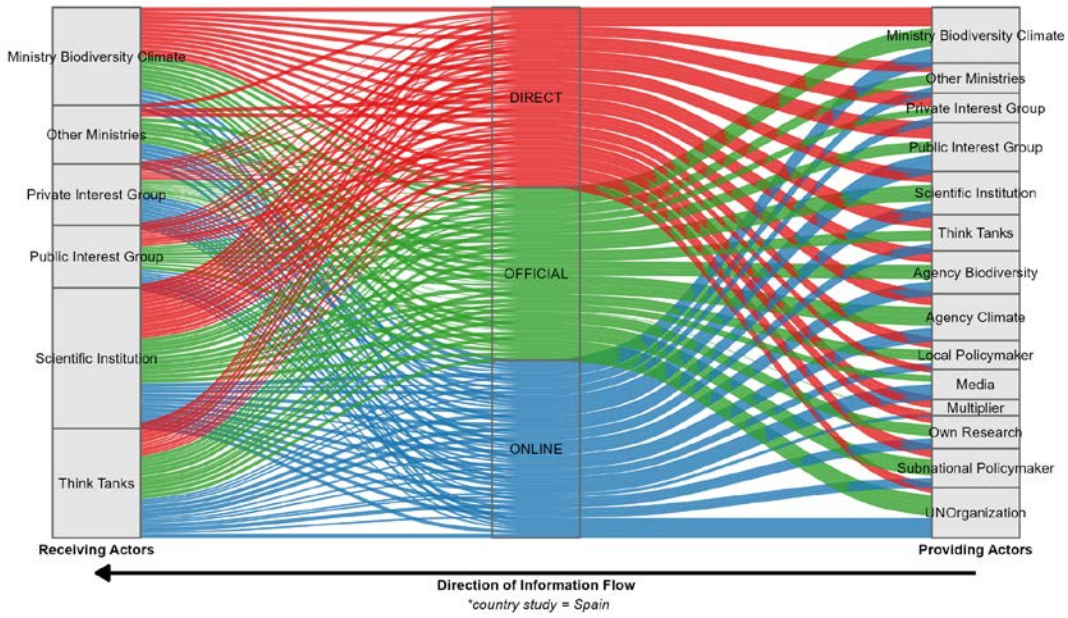

Figure ESP-2. Format-specific Sankey diagram showing how information from providers reaches receivers in Spain, segmented into three formats: Digital and online media (websites, social media, newsletters); Official and formal documents (reports, summary for decision-makers, IPCC reports, IPBES reports, information sheets) and Direct and indirect communication (emails, phone calls, expert advice, workshops, conferences)

This diagram breaks down the same information flows by format of exchange, allowing us to identify not just who is providing/receiving knowledge, but in how (jer,e in which format). The central column represents the format type. The left shows provider categories, and the right shows receivers. Flows are proportionally scaled to reported frequencies.

Scientific Institutions and Ministries distribute information across all three formats, but official and online formats dominate their exchanges. Direct exchange formats (e.g., workshops, face-to-face meetings) are especially prevalent between actors in public administration (Ministries and Interest Groups) highlighting the role of interpersonal trust and policy negotiations. Think Tanks and UN Organizations rely heavily on online formats, suggesting a more passive dissemination strategy that may limit uptake unless targeted more directly. The heavy use of official formats between Ministries may reflect bureaucratic norms, while the limited use of direct formats for marginalized actors like Multipliers or Local Policymakers suggests potential barriers to deliberative access. This distribution of formats implies a stratified communication ecosystem, where institutional actors have more diversified and formalized communication channels, while others remain restricted to singular formats or act mostly as receivers.

3.7.3.2 Receiver-Specific Information Flow

Each provider organization was visualized in terms of how it disseminates biodiversity and climate information to various receiving actor categories via three formats. Breaking down the interpretation by group we find the following:

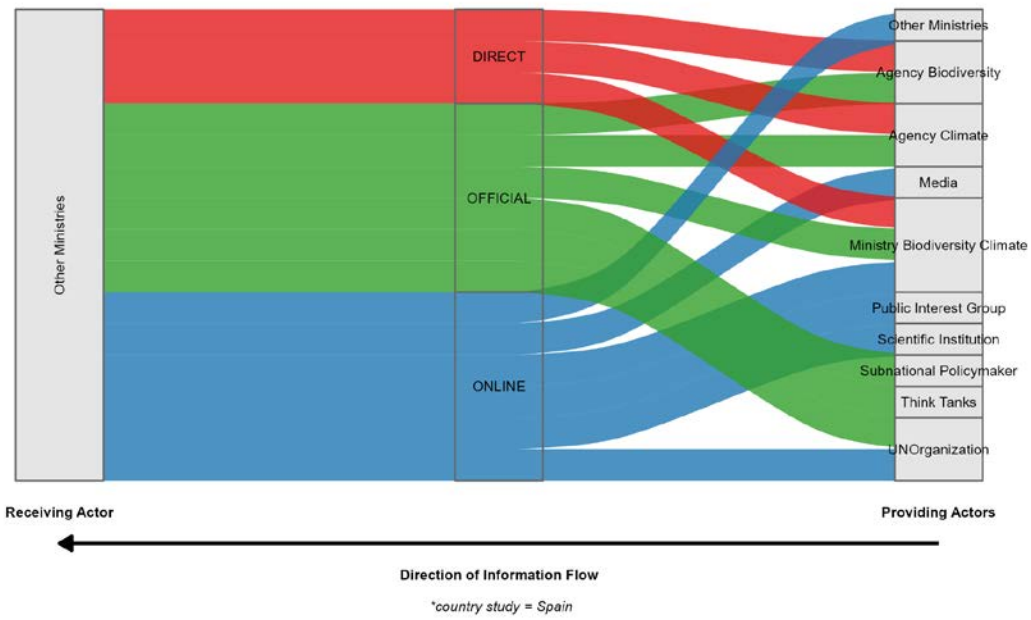

Figure ESP-3 . Receiver-Specific (Other Ministries) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

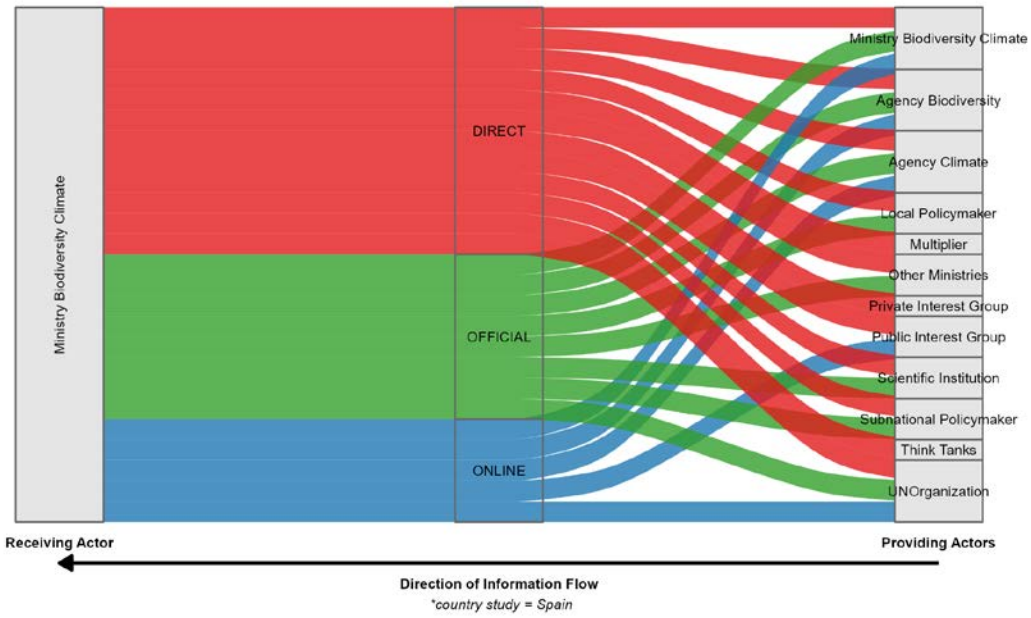

Figure ESP-4 . Receiver-Specific (Ministry responsible for Biodiversity and Climate) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

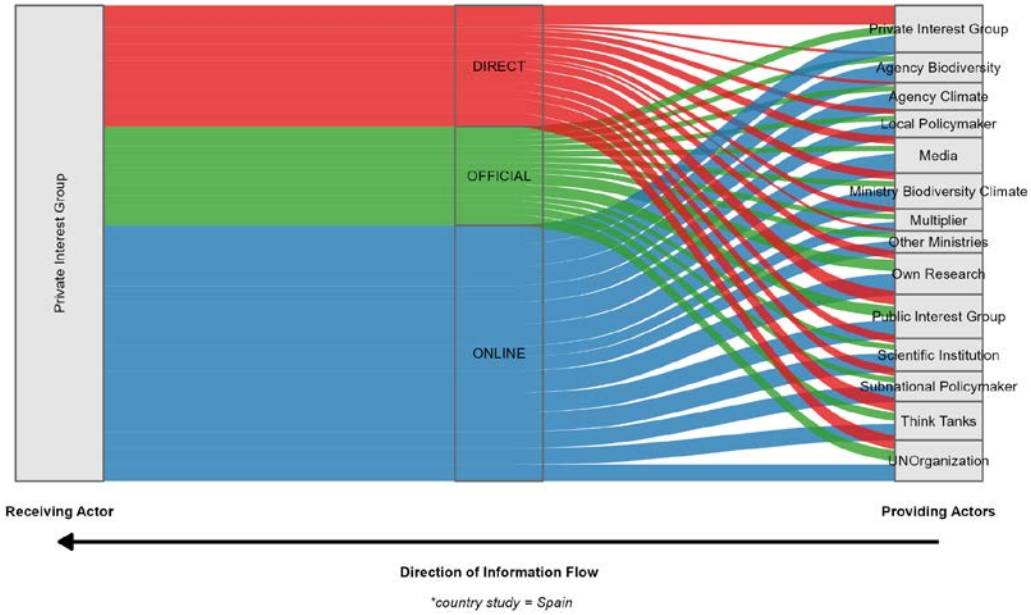

Figure ESP-5. Receiver-Specific (Private Interest Group) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

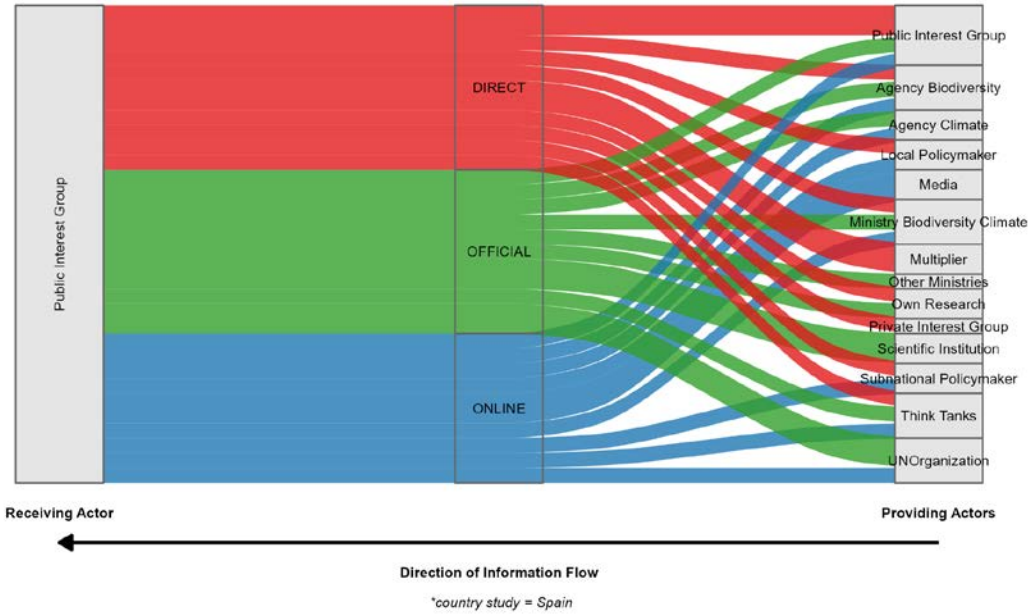

Figure ESP-6. Receiver-Specific (Public Interest Group) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

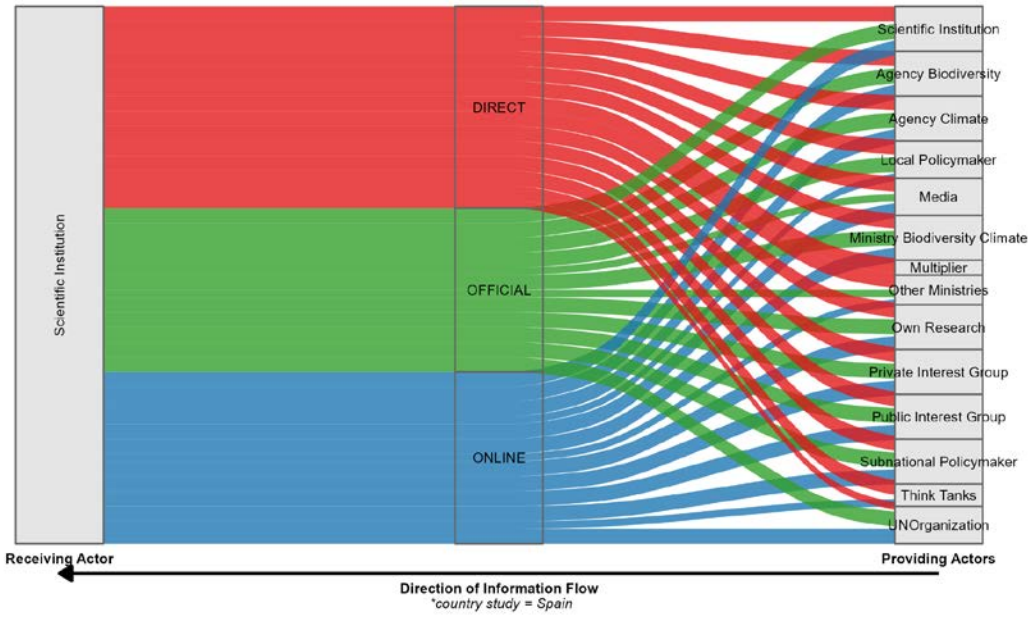

Figure ESP-7. Receiver-Specific (Scientific Institution) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

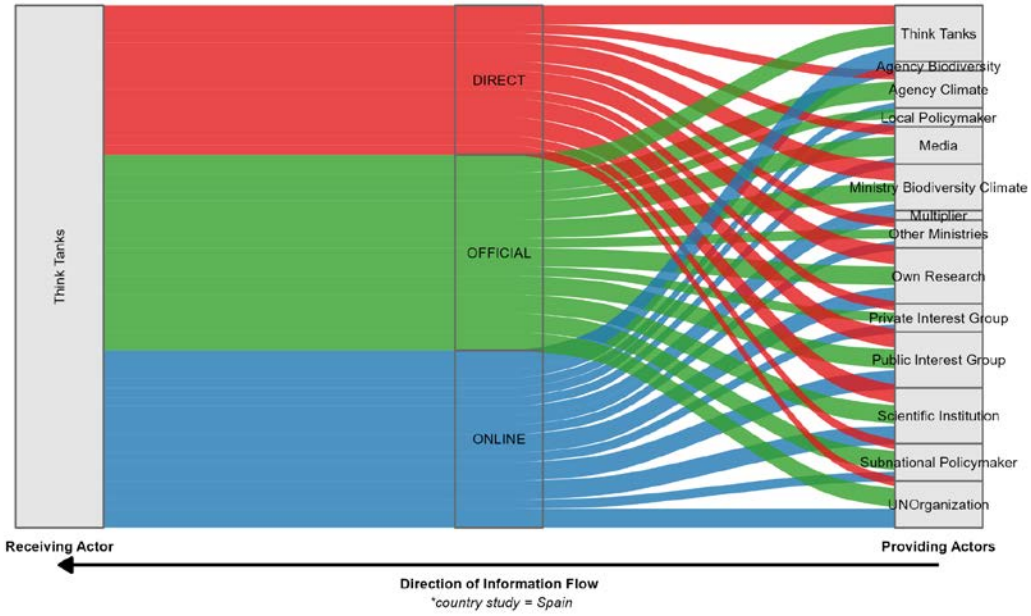

Figure ESP-8. Receiver-Specific (Think Tanks) Information Flow in Spain, segmented into three formats: DIRECT (e.g., meetings, calls), OFFICIAL (e.g., government reports), and ONLINE (e.g., websites, platforms).

I. Public Authorities (Ministries, Agencies, Sub-national and Local Policymakers)

For the Ministry of Biodiversity and Climate, we see a high volume across all formats, especially official and direct channels; Major receivers include other ministries, scientific institutions, and public interest groups. The Ministry fulfils a central coordinating role, maintaining formalized dissemination practices but also engaging in interpersonal exchanges — possibly through inter-ministerial task forces or workshops. This breadth signals institutional legitimacy but may also mask bureaucratic rigidity.

AgencyBiodiversity and AgencyClimate also rely on official documents, with AgencyClimate sending a notable portion via direct communication. Their recipients include Think Tanks, Scientific Institutions, and occasionally Private Sector actors.

For OtherMinistries, we observed a balanced use of online and official formats, moderate use of direct communication; Disseminates to a similar institutional cluster as the core ministry. This reflects a supportive, yet perhaps more passive, role in the knowledge system. Their reliance on formal channels may limit agility in engaging with civil society or scientific actors.

Subnational Policymakers and Local Policymakers rely more on direct communication, particularly with Ministries and Scientific Institutions, reflecting localized, relationship-based knowledge exchange. There is lower online activity compared to national ministries. These actors likely function in tight regional bureaucracies with fewer resources for maintaining online platforms, hence the reliance on face-to-face exchanges or governmental documentation. Further, LocalPolicymakers showed fewer total responses but prioritized direct and official formats over online. This suggests embeddedness in context-specific decision-making, where trust and interpersonal channels matter more than platform-based knowledge dissemination.

II. Scientific/ Research Actors and Knowledge Intermediaries

Scientific Institutions are among the most active providers. Their dominant formats are online and official, with key recipients being Ministries, Public Interest Groups, and Think Tanks. We see limited direct interaction. Scientific Institutions rarely engage in direct communication, and Private Sector actors are under-targeted by both groups. Research actors in Spain emphasize structured and public dissemination,

engaging with actors seen as relevant for policy and advocacy. However, the lack of direct, bilateral interaction may limit embedded uptake, especially outside the public sector.

Multipliers (e.g., training/extension organizations) seem to predominantly operate through online dissemination, with occasional official use. Their strategy appears to emphasize accessibility and reach, but the low proportion of direct interactions may limit their ability to contextualize knowledge for specific user groups.

III. Interest and Advocacy Groups

Public Interest Groups provide information mostly via direct communication, but also make use of online and official formats. Their most frequent recipients are Ministries, Scientific Institutions, and other NGOs. Suggests active engagement strategies: these actors not only inform the broader public but also directly influence institutional decision-making. Private Interest Groups lean more toward official and direct formats, sending information mostly to Ministries and Scientific Institutions. This group likely engages through targeted lobbying or formal commentaries, bypassing broad public dissemination. Their narrow format use may hinder transparency or broader legitimacy.

IV. Think Tanks and Capacity Buildings Organizations

Think Tanks provide information primarily to Ministries and Scientific Institutions, using official and online formats. This is consistent with their role as policy brokers, think tanks operate in deliberative spaces where informal trust, ideation, and advocacy are key. However, Private sector actors and local policymakers are rarely recipients of intermediary communication, and volume of information flows from multipliers is notably low.

UN actors primarily disseminate information through online formats, with a wide reach across multiple actor types, particularly ministries, scientific institutions, and public interest groups. Official channels are moderately used, while direct exchanges are comparatively limited or absent. This pattern reflects the global-to-national nature of UN bodies as centralized knowledge hubs, producing widely accessible digital materials rather than engaging in localized, bidirectional exchange. While this ensures broad dissemination, the lack of direct interaction may reduce opportunities for feedback, co-production, or contextual relevance, potentially limiting the perceived legitimacy or uptake of such information within national decision-making processes.

Cross-Cutting Observations

1. Direct formats are most actively used by Think Tanks, Private Interest Groups, and Subnational Policymakers: groups that often operate in informal or negotiated policy spaces.
2. Official formats dominate among ministries and bureaucratic actors, emphasizing formal legitimacy and documentation, but potentially limiting agility and co-production.
3. Online formats are heavily used by Scientific Institutions, Multipliers, and Public Interest Groups: emphasizing access and reach, but potentially missing influence among elite policy circles unless supplemented by other channels.
4. Low interaction diversity for some actors (e.g., UN Organizations, Multipliers) may reflect structural constraints or strategic narrowcasting, limiting their system-wide impact.

3.7.3.3 Links between Organizations

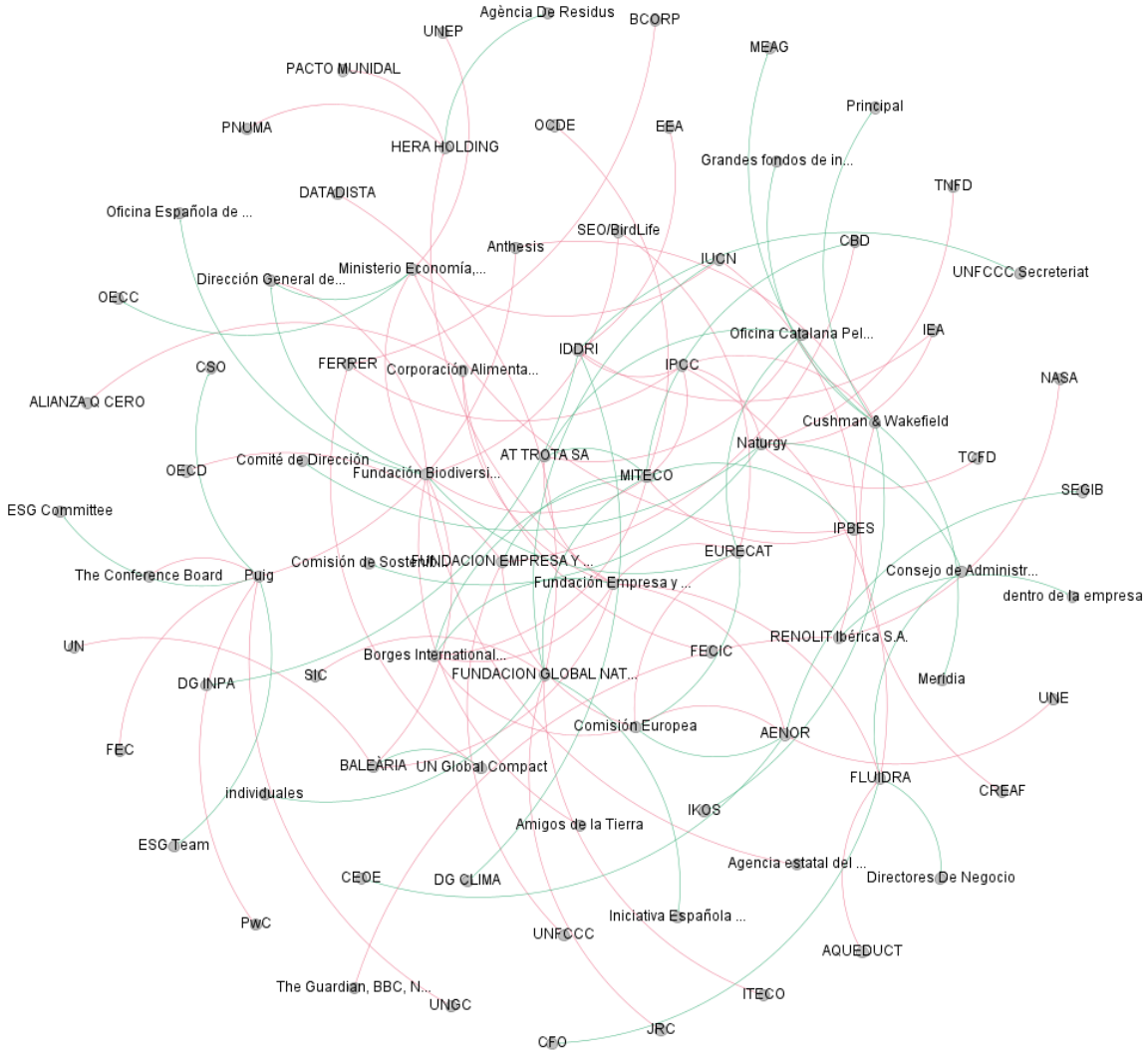

Fig ESP-9: Organization-level knowledge exchange network showing directional flows of biodiversity–climate information, as reported in open-text survey responses. Arrows indicate whether an organization was named as a frequent source (incoming flows, pink) or recipient (outgoing flows, green) of information. The thickness of each arrow corresponds to the frequency of mentions.

The organization-specific network for Spain reveals a concentrated and asymmetrical information system, anchored by a handful of prominent institutions that dominate both knowledge provision and receipt. The structure shows a clustering of actors around central state authorities, climate-focused business platforms, and international organizations, with relatively fewer pathways indicating mutual or horizontal exchange.

At the center of the network is MITECO (Ministerio para la Transición Ecológica y el Reto Demográfico), which appears as a major hub of both incoming and outgoing information flows. Its bidirectional connectivity reflects its role as Spain's primary public environmental authority and a central actor in processing, coordinating, and redistributing biodiversity and climate-related information across sectors. MITECO's engagement with ministries, private sector actors, and international platforms suggests that it functions as both a target and translator of technical information within the national policy system.

Fundación Empresa y Clima emerges as another central node, particularly prominent in its role as a provider of information. It serves as a key business-facing knowledge intermediary, supplying climate-related knowledge to government agencies, multilateral institutions, and corporate sustainability networks. Its outgoing connections far exceed its incoming ones, highlighting its position as a knowledge distributor rather than an interactive broker.

Civil society and scientific institutions, including Fundación Biodiversidad, SEO/BirdLife, and CREAF, play active roles as providers, primarily channeling information to national ministries, coordination platforms, and European bodies. However, these actors have relatively limited incoming connections, suggesting that their contributions to policy debates are outward-facing, rather than embedded within dialogical or iterative learning structures.

International bodies such as the IPCC, IPBES, CBD, UNFCCC, and the European Commission are positioned as prominent recipients of information from Spanish actors, in line with their global roles. However, the directionality of these flows suggests that international platforms continue to be treated as compliance reporting targets, rather than as sites of mutual exchange or co-production. The European Environment Agency (EEA), OECD, and JRC similarly appear on the receiving end, with little visible feedback from these organizations into the national system.

Private sector entities such as Naturgy, Renolit Iberica S.A., and Fluidra are present in the network but occupy largely peripheral positions. They are named as information recipients more than providers, reinforcing the notion that climate and biodiversity knowledge is being directed toward, rather than originating from, the business community. That said, some firms are linked to business coalitions or sustainability committees, indicating an emergent but still underdeveloped network of corporate environmental engagement.

Subnational authorities, regional platforms (e.g., Oficina Catalana Pel Canvi Climàtic), and independent think tanks or media actors remain largely peripheral. Their sparse connections suggest that Spain's biodiversity–climate knowledge system is still heavily centralized, with limited structural integration of localized knowledge or public-facing communicators into formal science-policy flows.

Overall, Spain's knowledge exchange network reflects a top-heavy configuration, characterized by central public agencies and international actors that receive information from a wide array of providers but offer relatively little feedback into the system. A small number of intermediaries, especially in the business–climate interface, serve as important transmitters, but the system lacks the density and bidirectionality typically associated with integrated, adaptive science-policy interfaces. This highlights an enduring gap in horizontal integration across sectors, and a tendency toward centralized, formalized flows of knowledge within Spain's biodiversity–climate policy interface[7]. Strengthening horizontal connections across sectors, particularly with local governments, media, academia, and the private sector, could improve the system's inclusivity, reflexivity, and long-term responsiveness.

[7] As in other countries' cases, the survey in Spain was designed to focus on government, civil society and private sector actors. Due to this sampling frame, the visibility of media, scientific institutions and subnational actors may be limited. We therefore exercise caution when interpreting apparent absences in the diagram, as they may reflect sampling and data collection gaps rather than an accurate description of the actual lack of involvement.

3.7.4 Facilitation and Improvement of Knowledge Exchange

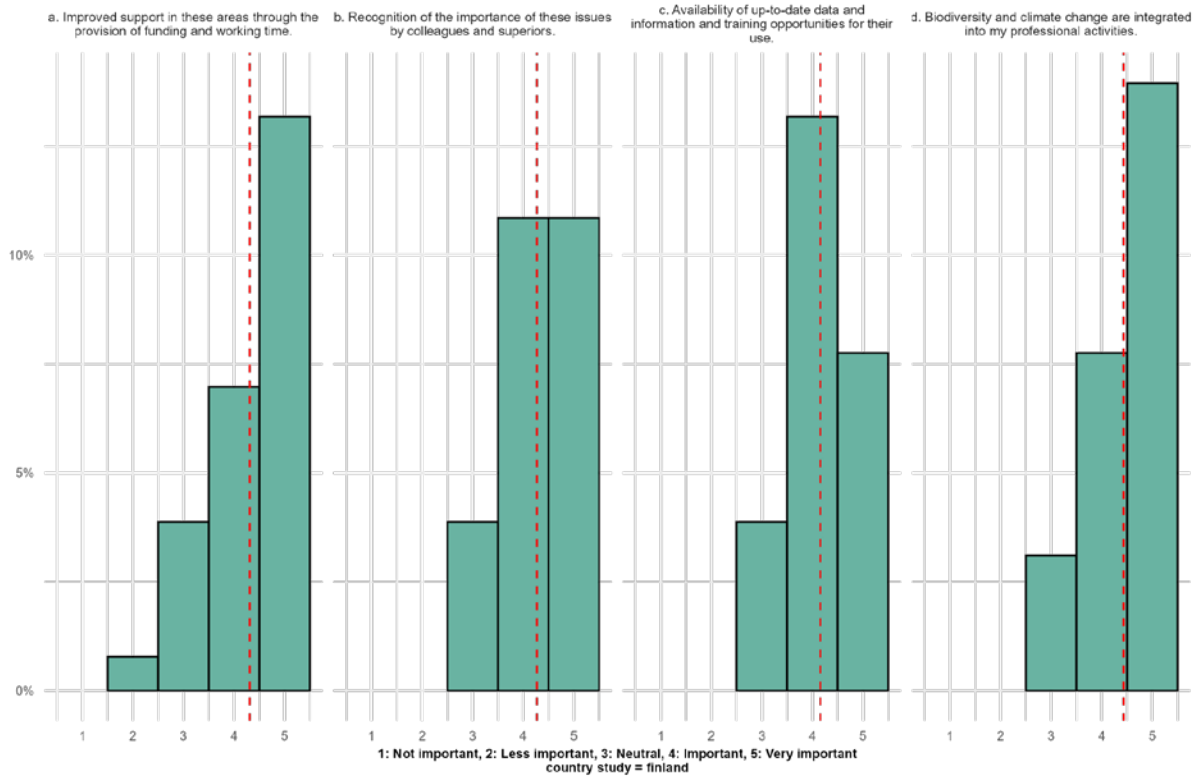

Figure ESP-10: Respondents' perceptions of institutional and professional support for integrating biodiversity and climate change into decision-making. Bars represent the percentage of respondents selecting each value on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The red dashed line indicates the mean response for each item.

The figure presents respondent perceptions across four dimensions related to institutional and professional support for biodiversity and climate change integration, measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Across all items, responses are skewed toward agreement (scores of 4 or 5), indicating generally positive assessments.

Institutional Support through Funding and Work Allocation: Respondents show high agreement with the statement regarding institutional support for biodiversity and climate efforts through funding and allocation of work time. Over 50% selected "5 – strongly agree," with a mean of 4.17, suggesting that many respondents feel their institutions are materially backing work in these areas.

Recognition by Colleagues and Supervisors: Perceptions of workplace recognition for climate and biodiversity relevance were slightly less strong, though still positive overall. The mean score is 3.95, with the largest share of respondents selecting "4" or "5." However, a noticeable minority of respondents selected neutral or low scores, indicating room for improvement in fostering shared professional awareness.

3. Availability of Up-to-Date Information and Training: Support in the form of access to current data and training opportunities received a mean score of 4.0, with most respondents agreeing or strongly agreeing. This suggests a moderate to strong institutional environment for ongoing learning, though a small share of respondents indicated dissatisfaction.

4. Integration into Professional Activities: Respondents indicated strong agreement that climate and biodiversity concerns are integrated into their professional activities, with the highest mean score of 4.21 among the four items. This suggests not only awareness, but operational uptake of these issues in daily responsibilities.

Overall, the data indicates a generally favourable institutional and professional environment for integrating

climate and biodiversity considerations. The strongest scores relate to direct integration into work and institutional resource support, while interpersonal recognition and access to training, though still positive, show slightly more variability.

Future Cooperation and Preferred Formats for Exchange

Respondents expressed interest in deepening collaboration with a wide range of actors across administrative levels and sectors. Public sector institutions included local and regional administrations, national agencies involved in biodiversity and climate strategies, and ministries such as MITECO, particularly the Oficina Española de Cambio Climático and the Subdirección General de Biodiversidad.

Sector-specific organizations, such as industry committees, Green Building Council Spain (GBCe), and the research institute CREAF, were also mentioned as strategic partners. On the international level, respondents named the European Environment Agency, multilateral institutions, and scientific bodies such as the IPCC as relevant counterparts for future cooperation.

Preferred formats of exchange included both in-person and digital modes, such as meetings, events, and email correspondence, alongside more structured formats like working groups, joint initiatives, and direct institutional engagement through policies or collaborative projects.

Recommendations for Enhancing Knowledge Dissemination and Uptake

Stakeholders in Spain identified several systemic improvements to ensure that biodiversity and climate knowledge is more effectively translated into policy and practice:

Clear, Accessible, and Targeted Communication: Respondents emphasized the need for simplifying language to reach non-expert audiences and for tailoring information to the needs of different sectors. They called for more regular, understandable, and sector-specific messaging to enhance relevance and accessibility.

Data Quality, Transparency, and Standardization: Enhancing the credibility and transparency of information was seen as essential. This included improving access to raw data, linking findings to original sources, and adopting standardized methodologies to ensure consistency across organizations. Building trust in the credibility of those communicating climate and biodiversity issues was also viewed as a critical priority.

Integration into Business and Governance Structures: Respondents stressed that biodiversity and climate considerations must be embedded in business operations and policy frameworks. Recommendations included monetizing environmental impacts, strengthening ESG governance within companies, and developing operational models that align sustainability with institutional mandates.

Knowledge Transfer and Expert Involvement: To bridge the science-policy gap, stakeholders suggested expanding the role of biodiversity and climate experts within decision-making processes. Creating direct communication channels between researchers and the private sector, and increasing the flow of technical and scientific knowledge across stakeholder groups, were highlighted as essential steps for improving uptake.

Overall, the Spanish responses reflect a strong call for improved communication, institutional integration, and cross-sector collaboration to ensure climate and biodiversity knowledge contributes meaningfully to policy and business decision-making.

4 Cross-Country Comparative Discussion and Policy Implications

4.1 How are knowledge systems structurally organized?

A review of the actor-category maps and chord diagrams shows that three structural archetypes, state-centred hubs, hybrid cores, and polycentric commons (see Table 1), recur across the seven countries. Each archetype channels agenda-setting power differently: highly centralised hubs enable rapid, top-down guidance; hybrid cores broaden debate but leave market actors peripheral; polycentric webs diffuse influence yet risk insider capture. These patterns confirm the network-governance literature: it is *incentives and trust*, not merely administrative tiers, that determine whether exchange becomes centralised or shared (Ostrom 2010; Provan & Kenis 2008).

Table: Dominant network architectures and their practical implications

Network architecture	How it showed up in the SNA	Countries observed	Potential implications
State-centred hub-and-spoke (Borgatti & Everett 2000)	One ministry or agency has the highest number of flows; most edges point to or from that node; chord diagram shows research → policy but little feedback.	Germany, DR Congo	Fast delivery of official guidance, but local authorities, media and business remain on the periphery.
Hybrid core (Provan & Kenis 2008)	Ministries remain large hubs, but NGOs or research co-share brokerage; bidirectional chords; mix of direct & online formats.	Colombia, Hungary	Broader debate than a pure hub, yet the private sector is still thinly connected.
Polycentric commons (Ostrom 2010)	Three or more categories have similar node sizes; edges form a dense web; ministries are *one* hub among several.	Finland, Spain, Armenia	Robust to single-node failure, but can become an *insider club* if new organisations lack entry points.

State-centered hub-and-spoke systems: environment ministries and their agencies dominate outgoing flows; other actors appear chiefly as receivers. Germany's BMUV–BfN pair anchors both the SNA map and chord diagram, with NGO and research flows directed to them rather than circulating horizontally. An analogous pattern centres on the Congolese biodiversity- and climate-related ministries. Survey comments from local authorities and SMEs report that "documents arrive too late to influence decisions," illustrating how hub control can mute peripheral voices.

Hybrid cores: Colombia still hinges on the Ministry of Environment and Sustainable Development, yet IDEAM and the von Humboldt Institute transmit substantial data back to the ministry, creating a two-way loop rather than a one-way funnel. Hungary likewise exhibits a tightly knit core in which research institutes, ministries and sub-national authorities all send information; nevertheless, business federations remain lightly connected.

Polycentric Commons: The Finnish network distributes large nodes across scientific institutes, ministries and NGOs; no single actor both sends *and* receives a majority of flows. Spain shows a similarly dense web, although relational formats concentrate among institutional actors, limiting access for local policymakers. Armenia is polycentric but compact, led by a handful of research institutes plus the Ministry of Environment, with scant lateral exchange among peers.

Hub-and-spoke systems deliver authoritative guidance rapidly, yet respondents at sub-national level often note that they "receive information too late or in inaccessible form." Polycentric webs provide multiple entry points, but free-text responses from Finland and Spain warn that "meetings tend to involve the same experts," hinting at insider dynamics despite structural openness. Hybrid cores lie between these poles: they

broaden deliberation, yet without incentives to enrol business and media actors, critical implementation pathways remain weak. These findings illustrate a central insight of network governance: who occupies the centre of a knowledge network shapes not only diffusion speed but also whose expertise is legitimised. The next sections examine how communication formats, brokerage roles and stakeholder priorities interact with these structural logics.

4.2 Preferred Communication Formats

Understanding how information is packaged is as important as the content itself. The Sankey diagrams in each country file track outgoing flows by channel and show that dominance[8] of a single format tends to stratify access, echoing behavioural-policy research on channel mismatch (Brick & Freeman 2021).

Table 2: Dominant communication channels and likely exclusions

Predominant format	General meaning (examples)	Countries	Likely to exclude
Document-heavy	Reports, Policy Briefs, Position papers	Germany, DR Congo	Small municipalities and SMEs (time & staff constraints).
Digital-first	Dashboards, open-data portals.	Finland, Colombia	Users without bandwidth or data-analysis skills.
Direct / relational	Meetings, calls, workshops, emails, trainings	Hungary, Armenia	Anyone outside tight professional circles.
Mixed formats	Parallel use of official reports, online access and interpersonal exchange.	Spain	Actors without formal roles or institutional ties to central organisations.

Survey results and Sankey data show that Germany and the DRC rely predominantly on policy briefs; respondents outside the central government flag time and bureaucratic burden as their chief obstacle to use. Finland and Colombia favour web portals and dashboards, extending geographic reach but this may oblige sub-national staff to interpret raw data without mediation. Hungary and Armenia distribute knowledge mainly through workshops and telephone contact; while participants praise the trust this builds, new actors may struggle to locate conversations that occur almost entirely offline. A modest but consistent pattern links format diversity, the simultaneous use of documents, data portals and dialogue, to higher average "ease-of-uptake" scores in the Likert items (Pearson $r \approx 0.4$ across the seven datasets). One of the implications here could be that where only one channel dominates, the actors least comfortable in that channel drift to the network fringe, regardless of how many reports or datasets are produced. Spain demonstrates a relatively diverse use of communication formats. Ministries and scientific institutions engage in formal document sharing, maintain online data platforms and participate in direct exchanges such as working groups and workshops. However, access to direct formats, such as workshops, expert consultations, and phone calls, emails, etc, appears stratified and disproportionately accessed by public administration and institutional actors, while local policymakers and non-governmental multipliers remain at the margins. This may suggest that while Spain employs multiple communication models, inclusivity depends on institutional affiliation and proximity to formal organisations.

[8] A country is classified as document-heavy, digital-first, or direct / relational when a single format ribbon represents ≥ 60 % of total outgoing flow in the Sankey diagram. A mixed-format classification is assigned when no single ribbon exceeds 50 % and at least two ribbons each account for ≥ 30 %.

The cross-country analysis shows that knowledge flow architecture, communication formats and brokerage capacity work together to shape whose knowledge counts in biodiversity–climate governance. In hub-and-spoke systems such as Germany and the DRC, a single ministry can disseminate authoritative guidance swiftly, yet local authorities, small businesses and journalists report that they receive material too late, or in a form too dense, to influence upstream choices. By contrast, the polycentric webs observed in Finland, Spain and Armenia distribute agenda-setting power across several actor categories, but they seem to likely rely on skillful gatekeepers to keep conversations permeable. These findings echo network-governance research which argues that effectiveness of knowledge uptake hinges less on density per se than on how central actors manage entry points and feedback loops (Provan & Kenis 2008).

Across five of the seven cases, three actor categories remain peripheral: private-sector federations, media outlets and think-tanks. Their thin or missing ties may mean market incentives, public deliberation and rapid policy synthesis draw on only a fraction of the available evidence base.

Brokerage: Across all seven cases, two-way translation between science and policy is strongest where NGOs or regional agencies are institutionally recognised and resourced to play that role. Where such brokers are absent, networks slide toward one-directional compliance reporting, exactly the condition that boundary-organisation theory warns against (Guston 2001). Funding programmes that set aside small, rapidly disbursed micro-grants for convening workshops, synthesis briefs or regional data clinics would close this gap at relatively low cost.

Formats: Reliance on a single channel, whether online, official documents or direct communication, could risk consistently marginalising actors whose skills, bandwidth or time budgets do not match that format. A simple "tri-format" requirement for publicly funded research outputs would oblige project teams to deliver a concise policy note, a machine-readable data file, and/or an interactive event. Communication-science experiments show that such layering markedly improves uptake across varied audiences (Brick & Freeman 2021).

Recognition and time: Survey respondents in every country highlight the lack of formal credit for engagement work. Allowing researchers and civil servants to charge a defined share of their time to stakeholder interaction may turn an unfunded expectation into a legitimate task.

Vertical loops: Devolving statutory mandates does little if no budget is attached to liaison. Finland and Colombia illustrate how regional agencies with modest but predictable resources can become central knowledge brokers. Future capacity-building schemes should therefore treat vertical brokerage as a deliverable in its own right, complete with monitoring indicators for reciprocal information flow.

Media and private sector. Five of the seven networks show near-invisibility of journalists and business federations. Without these links, scientific consensus may struggle to translate into market signals or public debate.

4.3 Improving How Scientific Knowledge Is Used: Insights from Stakeholders

Respondents across the seven countries articulated clear and recurring priorities for improving the uptake of biodiversity–climate knowledge. Qualitative synthesis of open-ended survey responses and workshop inputs reveals five thematic clusters that span institutional, political, and cultural domains of the science–policy interface.

Access to information and knowledge: There is widespread consensus on the need for simplified, targeted, and accessible scientific outputs. Respondents from Germany, Armenia, Finland, Colombia, and Hungary emphasize that complex findings must be reformulated into formats tailored to specific audiences - including policy briefs (which distil findings into actionable messages for decision-makers), position papers (which outline institutional perspectives), and case-based examples that illustrate locally relevant applications. These formats must remain accessible without being overly simplified. Several countries also call for standardized, interoperable data platforms; Germany and Armenia, in particular, advocate for both national and international coordination in this area. Colombia proposes a centrally networked digital portal.

Finland highlights the need to integrate heterogeneous data sources for a more complete picture of sustainability. A cross-cutting concern is the visibility and legitimacy of science in public discourse, with respondents in Hungary and Finland stressing that increased transparency is essential to rebuild trust.

Implementability of scientific findings: A recurring challenge is the translation of evidence into regionally feasible, actionable recommendation and strategies. Germany and Armenia stress the need to align scientific content with regional priorities and resource constraints. Colombia further highlights the importance of co-producing tools with local actors, ensuring regional knowledge is not only documented but also operationalized. Finland points to the need for projects to embed policy recommendations and illustrate feasibility through concrete examples. Many see transdisciplinary approaches from sustainability science (Lang et al. 2012) as a workable model: multi-actor teams that define problems jointly, iterate solutions and evaluate implementation together.

Political uptake: The integration of science into policy depends, above all, on political gatekeepers. Armenia and Colombia recommend structured training programmes for policymakers, especially to help them engage with complex knowledge sources and scenarios**,** such as those presented in IPCC and IPBES assessments. Hungary advocates permanent cross-sector expert forums to support decision-making, while Germany and Finland stress the need for legal and institutional mechanisms that compel political response to available information. Across cases, calls emerge for greater resource allocation—both financial and human—dedicated to evidence-based planning. Hungary notably calls for a broader political shift, arguing that without normative prioritization of environmental concerns, no amount of information will lead to transformative change.

Holistic and systemic thinking: Nearly all countries express frustration with sectoral fragmentation. There is strong support for integrated approaches that connect biodiversity and climate science to finance, land-use, health, and development planning. Respondents point to the need for frameworks that account for ecological costs in economic decisions and support interdisciplinary collaboration. Hungary highlights the need for sustained multi-disciplinary and inter-ministerial cooperation, echoing findings in Deliverable D3.2 on policy coherence. Respondents envision a governance architecture where data, mandates and budgets cut across siloed domains and enable whole-of-government solutions.

Communication and education: Respondents identify science communication and environmental education as long-term levers for social transformation. Germany, Armenia, Colombia, and Finland call for institutionalised dialogue formats between science, policy, and civil society. Finland notes that NGOs play a crucial communication role during electoral cycles, while Colombia emphasises targeted use of social media to engage youth. Germany and Colombia stress the importance of clear, professional media content to counter misinformation. Environmental education is seen as foundational in Germany, Hungary, Colombia, and Finland.

These findings align closely with the network analysis. Where formal structures concentrate power in a few hubs, respondents ask for decentralised access, capacity-building, and multiple voices in decision-making. Where polycentric exchange already exists, the emphasis shifts to coordination, usability, and continuity. What unifies these perspectives is a shared call for systems that are not just technically equipped, but also politically supported, socially legible, and institutionally accountable.

5. Practical Roadmap for Strengthening National Science-Policy Interfaces

Based on comparative insights from seven national cases, this section presents a practical roadmap of actionable steps to improve the uptake and usability of biodiversity and climate knowledge in national policy processes. While national contexts differ, a core set of needs emerges around institutional coordination, accessible formats, capacity-building, and inclusive knowledge flows. Please note that this is not an exhaustive list by any means, but we have tried to discuss some possible avenues for strengthening the interface.

Each recommendation specifies an example of a primary responsible actor and co-responsible partners. In general, primaries are ministries/agencies with legal mandate and budget for coordination or

implementation; co-responsibles are research funders and institutes, intermediary bodies/think tanks, National Focal Points (IPBES/IPCC), and subnational authorities.

5.1. Establish and fund dedicated knowledge brokerage roles

Stakeholders in Colombia, Hungary, and Spain emphasized the need for intermediaries who can translate complex global science into actionable national advice, navigate institutional silos, and foster inclusive dialogue. These actors are especially valuable in fragmented or polycentric systems.

Recommendation: Provide national or EU-level funding lines to support independent knowledge brokers, such as NGOs, regional platforms, or think tanks, that facilitate two-way translation between science and policy actors.

Primary responsible: Environment ministry or Centre of Government/Chancellery (coordination unit); **Co-responsible:** National research funder(s); public research institutes; statutory agencies; IPBES/IPCC NFPs.

5.2. Mandate multi-format dissemination of scientific outputs

Respondents in Finland, Germany, and Armenia noted that over-reliance on long-format reports limits access for time- and capacity-constrained actors, including local policymakers and SMEs. A multi-format strategy, one that combines concise policy briefs, interactive events, and open-access data could be used widely to improve accessibility and reach.

Recommendation: Adopt a tri-format dissemination requirement for all publicly funded research projects: (1) a concise policy note tailored to decision-makers, (2) a machine-readable dataset, and (3) an interactive engagement event (e.g. workshop or consultation).

Primary responsible: Public research funder(s); line ministries publishing national reports; **Co-responsible:** Lead institutes; knowledge intermediaries; NFPs.

5.3 Build institutional capacity for science uptake

In Armenia and Colombia, respondents called for structured training programs to help policymakers engage with complex knowledge sources and scenarios, such as those found in IPCC and IPBES assessments. Training was seen as critical for ensuring that scientific insights are not just available, but actionable.

Recommendation: Integrate modular science-policy training into existing planning mechanisms, focusing on the interpretation and application of global assessments in national and sectoral planning.

Primary responsible: Civil-service academy; HR/training units of line ministries; **Co-responsible:** Universities/professional schools; intermediaries; NFPs.

5.4 Assign responsibility for knowledge uptake to dedicated institutions

In Germany and Finland, stakeholders highlighted the absence of clearly mandated institutions responsible for synthesizing and circulating scientific knowledge within government. Without such focal points, knowledge uptake is fragmented and episodic.

Recommendation: Appoint or formalize science-policy focal points in relevant ministries or public agencies to lead internal coordination, knowledge synthesis, and the operational uptake of IPCC/IPBES findings.

Primary responsible: Centre of Government or named statutory evidence agency; **Co-responsible:** Environment/Economy ministries; National Statistics/Evidence Office.

5.5 Strengthen vertical and horizontal knowledge integration

Stakeholders in Spain, Hungary, and DRC stressed that national-to-local coordination remains weak, limiting the practical application of scientific guidance. Integrating vertical knowledge flows and fostering peer-to-peer exchange were seen as essential for implementation.

Recommendation: Establish regional coordination platforms or planning processes that systematically link national ministries, subnational authorities, and civil society to co-produce and adapt knowledge across levels.

Primary responsible: Interior/Regional Development ministry; Environment ministry; **Co-responsible:** Regional governments; municipal associations; e.g. basin/land-use authorities.

5.6 Develop national monitoring indicators for knowledge access and uptake

Several countries, including Germany and Colombia, noted that without formal mechanisms to track who accesses or uses scientific information, it's difficult to assess whether inclusion and uptake goals are being met.

Recommendation: Design and apply national-level indicators that monitor access to biodiversity and climate knowledge, disaggregated by actor type (e.g., ministries, businesses, NGOs) and governance level.

Primary responsible: National Statistics/Evidence Office; **Co-responsible:** Environment ministry; research funders; coordination lead.

5.7 Invest in long-term public science engagement and communication

Across all cases, stakeholders highlighted the need for sustained investment in environmental education and science communication. Civil society actors in Armenia, Hungary, and Spain stressed the value of media partnerships, peer learning, and public-facing formats in driving long-term change.

Recommendation: Fund communication strategies and education programs that strengthen public understanding and engagement with biodiversity and climate science, especially among marginalized or underrepresented groups.

Primary responsible: Science/Education ministry; public broadcaster(s); **Co-responsible:** Museums; NGOs; universities; media councils.

Annexe

R code used to quantitatively analyse survey questions (a variation used for different country cases)

```{r Packages}
# Load all Packages
library(tidyverse)
library(dplyr)
library(readxl)
library(readr)
library(writexl)
library(igraph)
library(ggraph)
library(ggplot2)
library(stringr)
library(ggalluvial)
library(RColorBrewer)
```

```{r Load and Clean Data}
# Read Data
data_COUNTRY <- read_excel("results-survey-COUNTRY.xlsx")
colnames(data_COUNTRY) <- paste0("col", seq_len(ncol(data_COUNTRY)))
# Standardize Names ActorCatReceiving [ADAPT TO EACH COUNTRY]
data_COUNTRY$col8[grepl("BMUV", data_COUNTRY$col8)] <- "MinistryBiodiversity"
data_COUNTRY$col8[grepl("BfN", data_COUNTRY$col8)] <- "AgencyBiodiversity"
data_COUNTRY$col8[grepl("Öffentliche Interessengruppen", data_COUNTRY$col8)] <- "PublicInterestGroup"
data_COUNTRY$col8[grepl("Regierung", data_COUNTRY$col8)] <- "OtherPolicymaker"
data_COUNTRY$col8[grepl("Think Tanks", data_COUNTRY$col8)] <- "ThinkTanks"
data_COUNTRY$col8[grepl("Medien", data_COUNTRY$col8)] <- "Media"
data_COUNTRY$col8[grepl("Private", data_COUNTRY$col8)] <- "PrivateInterestGroup"
data_COUNTRY$col8[grepl("Wissenschaftliche", data_COUNTRY$col8)] <- "ScientificInstitution"
```

```{r SNA + Sankey Base}
###### 1. Clean Data ######
```

```
# Select the columns: RespondentID (col 1), ActorCatReceiving (col 8) ActorCatProviding-Format (col 18:73) [ADAPT TO EACH COUNTRY]

data_COUNTRY_sna <- data_COUNTRY %>% select(1, 8, 18:73)


# Rename the first two columns for clarity

colnames(data_COUNTRY_sna)[1:2] <- c("RespondentID", "ActorCatReceiving")


# Rename the columns ActorCatProviding-Format using a systematic naming scheme [ADAPT TO EACH COUNTRY]

orgs <- c("MinistryBiodiversity", "MinistryClimate", "AgencyBiodiversity", "AgencyClimate",

        "SubnationalPolicymaker", "LocalPolicymaker", "PublicInterestGroup",

        "ScientificInstitution", "ThinkTanks", "Multiplier", "PrivateInterestGroup",

        "UNOrganization", "Media", "OwnResearch")


formats <- c("online", "official", "direct", "noinfo")

new_colnames <- paste0(rep(orgs, each = length(formats)), "_", rep(formats, times = length(orgs)))

start_col <- 3 #start at col 3

end_col <- start_col + length(new_colnames) - 1

colnames(data_COUNTRY_sna)[start_col:end_col] <- new_colnames

```

```{r SNA (Actor Category)}

###### 1. Transform into Edge List ######

#Respondent ID → Organization (Source) → Format (of Information) → Value (1/0), and then filter only the rows where Value = 1, meaning actual information received.

# pivot_longer() turns all Org_format columns into rows.

# separate() splits that into two columns: the provider (ActorCatProviding) and the format (Format).

# filter() keeps only the "1" (actual yes-flows) and drops the noinfo rows.

# Step 1: Transformation in Long Format

data_COUNTRY_sna_transform <- data_COUNTRY_sna %>%

  pivot_longer(

    cols = -c(RespondentID, ActorCatReceiving),

    names_to = "ActorCatProviding_Format",

    values_to = "InformationFlow"   )
```

```
# Step 2: Seperate  "ActorCatProviding_Format" in "ActorCatProviding" and "Format"

data_COUNTRY_sna_transform <- data_COUNTRY_sna_transform %>%

  separate(ActorCatProviding_Format, into = c("ActorCatProviding", "Format"), sep = "_")  # seperate  "_" in two parts

# step 3: Only keep the columns with "InformationFlow" = 1, exclude "noinfo"

edge_list <- data_COUNTRY_sna_transform %>%

  filter(InformationFlow == 1, Format != "noinfo") %>%

  select(RespondentID, ActorCatReceiving, ActorCatProviding, Format, InformationFlow)

###### 3. Create Aggregated + Weighted Edge List ######

# Compute total respondents per "receiver" category.

# Normalize by dividing each pair's count by its receiver's total, yielding a proportion (0–1).

# Step 1: Aggregate edge list --> for each unique pair (Receiver, Provider ->independent of format), count how many respondents reported the flow.

edge_list_aggregated <- edge_list %>%

  distinct(RespondentID, ActorCatReceiving, ActorCatProviding) %>%

  group_by(ActorCatReceiving, ActorCatProviding) %>%

  summarise(Weight = n(), .groups = 'drop')

# Step 2: Sum of Respondents per ActorCatReceiving

respondents_counts <- as.data.frame(table(data_COUNTRY_sna$ActorCatReceiving))

colnames(respondents_counts) <- c("ActorCatReceiving", "TotalResponses")

# Step 3: Join the aggregated edge list with the respondent counts and create the normalized flow

edge_list_weighted <- edge_list_aggregated %>%

  left_join(respondents_counts, by = "ActorCatReceiving")

edge_list_weighted <- edge_list_weighted %>%

  mutate(NormalizedFlow = Weight / TotalResponses) %>%  # This value will be between 0 and 1 --> represents the share of "yes" answers per receiver-provider flos (aggregated flows / total respondents per ActorCatReceicing)

  select(ActorCatReceiving, ActorCatProviding, NormalizedFlow)

# edge_list_weighted includes: ActorCatReceiving, ActorCatProviding, NormalizedFlow

###### 4. Create Network ######

# Create Network, Assign node size + colors, labels

# Create igraph object

# Compute node size from total outgoing (providing) flow

# Pre-define provider colours, fallback for pure-receivers
```

```
# Split CamelCase & wrap long labels for readability
# Step 1: Create a directed graph
g <- graph_from_data_frame(d = edge_list_weighted, directed = TRUE)
# Step 2: Set node size based on summed NormalizedFlow per 'ActorCatProviding' (i.e., ActorCatProviding)
node_size <- edge_list_weighted %>%
  group_by(ActorCatProviding) %>%
  summarise(Sum = sum(NormalizedFlow, na.rm = TRUE)) %>%
  arrange(desc(Sum))
V(g)$size <- node_size$Sum[match(V(g)$name, node_size$ActorCatProviding)]
V(g)$size[is.na(V(g)$size)] <- 0
max_size <- ceiling(max(V(g)$size, na.rm = TRUE))
# Step 3: Define specific colors for known providing organizations.
org_colors <- c(
  # Ministries
  "MinistryBiodiversity"   = "#1F78B4",
  "MinistryClimate"        = "#559EDC",
  "OtherMinistries"        = "#A6CEE3",
  # Agencies
  "AgencyBiodiversity"     = "#4DAF4A",
  "AgencyClimate"          = "#B2DF8A",
  # Policymakers
  "SubnationalPolicymaker" = "#E66101",
  "LocalPolicymaker"       = "#F8961E",
  "OtherPolicymaker"       = "#FDBF6F",
  #Other Providers
  "PublicInterestGroup"    = "#8B0000",
  "ScientificInstitution"  = "#E78AC3",
  "ThinkTanks"             = "#D73027",
  "Multiplier"             = "#FFD92F",
  "PrivateInterestGroup"   = "#6A3D9A",
  "UNOrganization"         = "#1BCED4",
  "Media"                  = "#A6761D",
  "OwnResearch"            = "#999999"
```

```
)
# Use "Receiving Only" for any node name not among known providers.
default_group <- "Receivers"
# Create a new vertex attribute "org_type".
# For vertices whose name is in org_colors, use that; otherwise assign default_group.
V(g)$org_type <- ifelse(V(g)$name %in% names(org_colors),
                        V(g)$name,
                        default_group)
# Create a color mapping that includes both the organization colors and a color for "Receiving Only".
custom_colors   <- c(org_colors, "Receivers" = "#FFF")
# ensure legend breaks/labels match
org_types <- names(custom_colors)
# Step 4: Set node labels
V(g)$label <- V(g)$name
# Clean up labels
V(g)$label <- V(g)$name %>%
  gsub("([a-z])([A-Z])", "\\1 \\2", .) %>%  # split CamelCase
  str_wrap(width = 15)                      # wrap long names
###### 6. Visualize Network ######
# Visualize the Network Map with ggraph (without arrows)
# Edges thickness encodes the normalized flow.
# Node points size and color encode total outgoing flow and org type.
# Labels repel each other to avoid overlap.
# Legends and title are added, then the map is saved as a PNG.
sna_plot <- ggraph(g, layout = "fr") +
  # Draw edges with reduced thickness and without arrows
  geom_edge_link(aes(width = NormalizedFlow),
                 # Removed arrow and end_cap parameters
                 color = "grey50",
                 alpha = 0.7) +
  # Draw nodes: map size (Total Outgoing Flow) and color (Organization Type)
  geom_node_point(aes(size = size, color = org_type),
                  show.legend = TRUE,
```

```
            alpha = 0.9
) +
# Add labels to nodes with repulsion to prevent overlap
geom_node_text(aes(label = label),
            repel       = TRUE,
            size        = 3,
            fontface    = "bold",   # ← make labels bold
            color       = "black") +
# Customize edge width (for visual reference only)
scale_edge_width(range = c(0.2, 2), name = "Normalized Info Flow") +
# Set node size legend: hierarchical breaks in 1er Schritten
scale_size_continuous(range = c(3, 12),
                  name = "Total Outgoing Flow",
                  breaks = seq(0, max_size, by = 1)
) +
# Map the node colors using a manual scale with the legend "Organization Type"

scale_color_manual(name = "Organization Type", values = custom_colors, breaks = org_types,
                labels = org_types,
                drop = FALSE
) +
# clean look + title
labs(title = "Social Network, country study = COUNTRY") +
theme_void() +
theme(
  legend.position = "none",
  plot.title = element_text(
    size = 10,
    face = "italic",
    family = "Arial",
    hjust = 0.5
  )
)
```

```
print(sna_plot)


# Save
ggsave("sna_map.png", plot = sna_plot,
       width = 8, height = 6, dpi = 300)
```{r Sankey Diagram Total}
###### 2. Transform to edge list ######
data_COUNTRY_sna_transform <- data_COUNTRY_sna %>%
  pivot_longer(cols = -c(RespondentID, ActorCatReceiving), names_to = "ActorCatProviding_Format", values_to = "InformationFlow") %>%
  separate(ActorCatProviding_Format, into = c("ActorCatProviding", "Format"), sep = "_")


edge_list <- data_COUNTRY_sna_transform %>%
  filter(InformationFlow == 1, Format != "noinfo") %>%
  select(RespondentID, ActorCatReceiving, ActorCatProviding, Format, InformationFlow)


###### 3. Aggregate including Format ######
edge_list_aggregated_format <- edge_list %>%
  distinct(RespondentID, ActorCatReceiving, ActorCatProviding, Format) %>%
  group_by(ActorCatReceiving, ActorCatProviding, Format) %>%
  summarise(Weight = n(), .groups = 'drop')
respondents_counts <- as.data.frame(table(data_COUNTRY_sna$ActorCatReceiving))
colnames(respondents_counts) <- c("ActorCatReceiving", "TotalResponses")


edge_list_weighted_format <- edge_list_aggregated_format %>%
  left_join(respondents_counts, by = "ActorCatReceiving") %>%
  mutate(NormalizedFlow = Weight / TotalResponses) %>%
  select(ActorCatReceiving, ActorCatProviding, Format, NormalizedFlow)


###### 4. Prepare Sankey diagram ######
split_camel_case <- function(x) {
  gsub("([a-z])([A-Z])", "\\1 \\2", x)
```
```

```
}
sankey_data_format <- edge_list_weighted_format %>%
  select(ActorCatReceiving, Format, ActorCatProviding, NormalizedFlow) %>%
  mutate(ActorCatReceiving = split_camel_case(ActorCatReceiving),
         ActorCatProviding = split_camel_case(ActorCatProviding),
         Format = toupper(Format))

format_colors <- c(
  "ONLINE"   = "#1f78b4",
  "OFFICIAL" = "#33a02c",
  "DIRECT"   = "#e31a1c"
)
###### 5. Visualization ######
sankey_plot_format <- ggplot(sankey_data_format,
                             aes(axis1 = ActorCatReceiving,
                                 axis2 = Format,
                                 axis3 = ActorCatProviding,
                                 y = NormalizedFlow)) +

  # Color flows by format
  geom_alluvium(aes(fill = Format), width = 1/12, alpha = 0.8) +
  scale_fill_manual(values = format_colors, name = "Format") +

  # Start new fill scale for stratum
  ggnewscale::new_scale_fill() +

  # Stratum blocks: color middle axis, others gray
  geom_stratum(
    aes(fill = ifelse(after_stat(x) == 2, stratum, "grey90")),
    width = 1/5,
    color = "grey40"
  ) +
  scale_fill_manual(values = c(format_colors, "grey90" = "grey90"), na.translate = FALSE, guide = "none") +
```

```
# Labels
geom_text(stat = "stratum",
          aes(label = after_stat(stratum),
              angle = after_stat(ifelse(x == 2, 0, 0))),
          size = 3,
          fontface = "plain",
          color = "black")+

scale_x_discrete(breaks = c(1, 2, 3),
                 labels = c("Receiving Org.", "Format", "Providing Org."),
                 expand = c(.05, .05)) +

labs(title = "",
     x = "") +

coord_cartesian(clip = "off") +
theme_classic() +
theme(
  panel.grid.major.x = element_blank(),
  plot.margin = margin(t = 5, r = 50, b = 5, l = 5),
  axis.title.y = element_blank(),
  axis.text.y = element_blank(),
  axis.ticks.y = element_blank(),
  axis.line.y = element_blank(),
  legend.position = "none"
) +

annotate("segment",
         x = 3, xend = 1,
         y = -9, yend = -9,
         colour = "black", size = 1,
         arrow = arrow(length = unit(0.3, "cm"), type = "closed")) +
```

```
  annotate("text",
           x = 2, y = -12,
           label = "Direction of Information Flow",
           size = 3,
           fontface = "bold",
           color = "black") +

  annotate("text", x = 1, y = -3, label = "Receiving Actors",
           size = 3, fontface = "bold") +
  annotate("text", x = 3, y = -3,, label = "Providing Actors",
           size = 3, fontface = "bold") +
  annotate("text", x = 2, y = -17, size = 3, fontface = "italic", label = " *country study = COUNTRY")

print(sankey_plot_format)

# Save plot
ggsave("sankey_diagram_format_colored_middle.png",
       plot = sankey_plot_format,
       width = 10, height = 6,
       dpi = 300)

```

```{r Receiver-Specific Sankey}

####### 1. Create individual Sankey diagrams for each receiver #######
sankey_data_actor <- edge_list_weighted_format %>%
  mutate(Format = toupper(Format)) %>%
  select(ActorCatReceiving, Format, ActorCatProviding, NormalizedFlow)

sankey_data_actor <- edge_list_weighted_format %>%
  mutate(
```

```
    Format = toupper(Format),
    ActorCatReceiving = gsub("([a-z])([A-Z])", "\\1 \\2", ActorCatReceiving),
    ActorCatProviding = gsub("([a-z])([A-Z])", "\\1 \\2", ActorCatProviding)
  ) %>%
  select(ActorCatReceiving, Format, ActorCatProviding, NormalizedFlow)

# Use the same color palette
format_colors <- c(
  "ONLINE"   = "#1f78b4",
  "OFFICIAL" = "#33a02c",
  "DIRECT"   = "#e31a1c"
)

# List of all receiving actors
Receiving <- unique(sankey_data_actor$ActorCatReceiving)

####### 2. Visualization #######
sankey_list <- lapply(Receiving, function(rec) {
  df_sub <- sankey_data_actor %>% filter(ActorCatReceiving == rec)



  p <- ggplot(df_sub,
              aes(axis1 = ActorCatReceiving,
                  axis2 = Format,
                  axis3 = ActorCatProviding,
                  y     = NormalizedFlow)) +

    geom_alluvium(aes(fill = Format), width = 1/12, alpha = 0.8) +
    scale_fill_manual(values = format_colors, name = "Format") +

    ggnewscale::new_scale_fill() +

    geom_stratum(
```

```
  aes(fill = ifelse(after_stat(x) == 2, stratum, "grey90")),
  width = 1/5,
  color = "grey40"
) +
scale_fill_manual(values = c(format_colors, "grey90" = "grey90"), na.translate = FALSE, guide = "none") +

geom_text(stat = "stratum",
        aes(label = after_stat(stratum),
           angle = after_stat(case_when(
             x == 1 ~ 90,
             TRUE   ~ 0
           ))),
        size = 3,
        fontface = "plain",
        color = "black")+

scale_x_discrete(
  breaks = c(1, 2, 3),
  labels = c("Receiving Org.", "Format", "Providing Org."),
  expand = c(.05, .05)
) +

labs(title = "" ,
     x = "", y = "") +

coord_cartesian(clip = "off") +
theme_classic() +
theme(
  panel.grid.major.x = element_blank(),
  plot.margin = margin(t = 5, r = 50, b = 5, l = 5),
  axis.title.y = element_blank(),
  axis.text.y = element_blank(),
  axis.ticks.y = element_blank(),
```

```
    axis.line.y = element_blank(),
    legend.position = "none"
  ) +

  annotate("segment",
           x = 3, xend = 1,
           y = -2, yend = -2,
           colour = "black", size = 1,
           arrow = arrow(length = unit(0.3, "cm"), type = "closed")) +

  annotate("text",
           x = 2, y = -3,
           label = "Direction of Information Flow",
           size = 3,
           fontface = "bold",
           color = "black") +

  annotate("text", x = 1, y = -1, label = "Receiving Actor",
           size = 3, fontface = "bold") +
  annotate("text", x = 3, y = -1,, label = "Providing Actors",
           size = 3, fontface = "bold") +
  annotate("text", x = 2, y = -4, size = 3, fontface = "italic", label = " *country study = COUNTRY")

# Save each plot
ggsave(
  filename = paste0("sankey_", gsub(" ", "_", rec), ".png"),
  plot     = p,
  width    = 10,
  height   = 6,
  dpi      = 300
)

return(p)
```

```
})

# Show all Sankey plots in RStudio
for (p in sankey_list) {
  print(p)
}
```

```{r SNA Networm (incl. detailed names of organizations)}

###### 1. Read + Clean Data ######
data_COUNTRY_qualitative <- read_excel("results-survey-COUNTRY-qualitative.xlsx")
data_COUNTRY_qualitative <- data_COUNTRY_qualitative %>% select(1:13)

colnames(data_COUNTRY_qualitative)[1:13] <- c("RespondentID", "Organization", "ActorCatReceiving", "Q5(1)","Q5(2)","Q5(3)","Q5(4)","Q5(5)","Q8(1)","Q8(2)","Q8(3)","Q8(4)", "Q8(5)")

# [ADAPT TO EACH COUNTRY]
data_COUNTRY_qualitative$ActorCatReceiving[grepl("BMUV", data_COUNTRY_qualitative$ActorCatReceiving)] <- "MinistryBiodiversity"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("BfN", data_COUNTRY_qualitative$ActorCatReceiving)] <- "AgencyBiodiversity"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Öffentliche Interessengruppen", data_COUNTRY_qualitative$ActorCatReceiving)] <- "PublicInterestGroup"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Regierung", data_COUNTRY_qualitative$ActorCatReceiving)] <- "OtherPolicymaker"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Think Tanks", data_COUNTRY_qualitative$ActorCatReceiving)] <- "ThinkTanks"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Medien", data_COUNTRY_qualitative$ActorCatReceiving)] <- "Media"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Private", data_COUNTRY_qualitative$ActorCatReceiving)] <- "PrivateInterestGroup"
data_COUNTRY_qualitative$ActorCatReceiving[grepl("Wissenschaftliche", data_COUNTRY_qualitative$ActorCatReceiving)] <- "ScientificInstitution"

####### 2. Create edge-list for received + forwarded information ######
receiving_edges <- data_COUNTRY_qualitative %>%
```

```
  select(Organization, `Q5(1)`:`Q5(5)`) %>%
  pivot_longer(
    cols      = starts_with("Q5"),
    names_to  = "q5_order",
    values_to = "Content"
  ) %>%
  filter(!is.na(Content), Content != "") %>%
  transmute(
    source     = Content,
    target       = Organization,
    relation = "received"
  )

forwarding_edges <- data_COUNTRY_qualitative %>%
  select(Organization, `Q8(1)`:`Q8(5)`) %>%
  pivot_longer(
    cols      = starts_with("Q8"),
    names_to  = "q8_order",
    values_to = "Content"
  ) %>%
  filter(!is.na(Content), Content != "") %>%
  transmute(
    source     = Organization,
    target       = Content,
    relation = "forwarded"
  )

# combining both rows
edges <- bind_rows(receiving_edges, forwarding_edges)

# Save as Excel --> use as input for Gephi
write_xlsx(edges, "Edges_SNA_COUNTRY.xlsx")
```

```
```{r Base for Descriptive Information}

###### 1. Read + Clean Data ######

# select relevant columns [ADAPT TO EACH COUNTRY]
data_COUNTRY_results <- data_COUNTRY %>% select(1,8,13:16,77:80)

colnames(data_COUNTRY_results)[2] <- "ActorCatReceiving"
colnames(data_COUNTRY_results)[1] <- "RespondentID"
colnames(data_COUNTRY_results) [3] <- "I make decisions that include biodiversity and climate change issues."
colnames(data_COUNTRY_results) [4] <- "I provide technical or professional expertise that informs decision-making processes."
colnames(data_COUNTRY_results) [5] <- "I communicate or forward relevant recommendations within my organization to support decision-making."
colnames(data_COUNTRY_results) [6] <- "Other Role"

colnames(data_COUNTRY_results) [7] <- "a. Improved support in these areas through the provision of funding and working time. "
colnames(data_COUNTRY_results) [8] <- "b. Recognition of the importance of these issues by colleagues and superiors."
colnames(data_COUNTRY_results) [9] <- "c. Availability of up-to-date data and information and training opportunities for their use."
colnames(data_COUNTRY_results) [10] <- "d. Biodiversity and climate change are integrated into my professional activities."

```

```{r Information on Respondents (Q4)}

###### Q4: Contribution in Organization (TOTAL) ###### [ADAPT "Yes" TO COUNTRY LANGUAGE]
Q4_data <- data_COUNTRY_results %>% select(3:5) %>%
  summarise(across(everything(), ~ sum(.x == "Yes", na.rm = TRUE))) %>%
  pivot_longer(cols = everything(), names_to = "Contribution", values_to = "Yes_Count")
```
```

```
p1 <- ggplot(Q4_data, aes(x = Contribution, y = Yes_Count)) +
  geom_col(fill = "steelblue") +
  labs(
    title = "What contribution do you make in your professional role with regard to the provision and transfer of information on biodiversity and climate change?",
    x = "Contribution",
    y = "Count of 'Yes'"
  ) +
  theme_minimal()+
  # wrap the very long labels
  scale_x_discrete(
    labels = function(x) str_wrap(x, 20),
    expand = expansion(add = 0.5)   # gives half-bar width padding at ends
  ) +

  # rotate and centre the text
  theme(
    axis.text.x = element_text(
      angle = 45,
      hjust = 0.5,    # ← centre each label on its tick
      vjust = 1,
      size  = 10
    )
  )

print(p1)
ggsave("Q4_total_contributions.png", plot = p1,
       width = 8, height = 5, dpi = 300)

###### Q4: Contribution in Organization (BY ACTOR CATEGORY) ######

Q4_data_org <- data_COUNTRY_results %>%
```

```
  pivot_longer(cols = 3:5, names_to = "Contribution", values_to = "Yes_Count") %>%
  filter(Yes_Count == "Yes")

summary_stacked <- Q4_data_org %>%
  group_by(ActorCatReceiving, Contribution) %>%
  summarise(Yes_Count = n(), .groups = "drop")

summary_stacked <- summary_stacked %>%
  group_by(ActorCatReceiving) %>%
  mutate(Percentage = Yes_Count / sum(Yes_Count) * 100) %>%
  ungroup()

p2 <-ggplot(summary_stacked, aes(x = ActorCatReceiving, y = Yes_Count, fill = Contribution)) +
  geom_col(position = "stack") +
  geom_text(
    aes(label = paste0(round(Percentage), "%")),
    position = position_stack(vjust = 0.5),
    color = "black",
    size = 3
  ) +
  labs(
    title = "What contribution do you make in your professional role with regard to the provision and transfer of information on biodiversity and climate change? (per Actor Category)",
    x = "Actor Category (Receiving)",
    y = "Proportion of Responses",
    fill = "Contribution"
  )+
  # wrap the very long Contribution names in the legend:
  scale_fill_discrete(
    labels = function(x) str_wrap(x, width = 25)
  ) +
  theme_minimal() +
  theme(
```

```
  axis.text.x = element_text(angle = 45, hjust = 1),
  legend.position = "bottom"
 )

print(p2)
ggsave("Q4_by_actor_contributions.png",
       plot   = p2,
       width  = 9,
       height = 6,
       dpi    = 300)
```

```{r Improvement of Knowledge Exchange}

###### Q10 (Total) ######

Q10_data <- data_COUNTRY_results %>%
  pivot_longer(cols = 7:10,
               names_to = "Statement",
               values_to = "Agreement")

mean_values <- Q10_data %>%
  group_by(Statement) %>%
  summarise(mean_agreement = mean(Agreement, na.rm = TRUE))

p3 <- ggplot(Q10_data, aes(x = Agreement)) +
  geom_bar(aes(y = (..count..)/sum(..count..)),
           fill = "#69b3a2", color = "black", stat = "count", width = 1) +
  scale_x_continuous(breaks = 1:5, limits = c(0.5, 5.5)) +
  facet_wrap(~ Statement, ncol = 4, scales = "fixed", labeller = label_wrap_gen(width = 50)) +

  labs(title = "Facilitation of Knowledge Exchange (Agreement to Statements)",
```

```
    x = "1: Not important, 2: Less important, 3: Neutral, 4: Important, 5: Very important\ncountry study = COUNTRY",
    y = "%") +
  geom_vline(data = mean_values, aes(xintercept = mean_agreement),
             linetype = "dashed", color = "red", size = 0.5) +
  geom_text(data = mean_values, aes(x = mean_agreement, y = 0.01,
                                    label = paste("mean:", round(mean_agreement, 2))),
            color = "red", size = 3, angle = 90, vjust = -1, hjust = -8) +
  scale_y_continuous(labels = scales::percent) +
  theme_minimal(base_size = 12) +
  theme(
    strip.text = element_text(size = 7),
    axis.title.x = element_text(size = 7, face = "bold"),
    axis.title.y = element_blank(),
    plot.title = element_blank(),
    axis.text.x = element_text(size = 7),
    axis.text.y = element_text(size = 7)
  )

print(p3)
ggsave("Q10_total_agreement.png",
       plot   = p3,
       width  = 9,
       height = 6,
       dpi    = 300)
```

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