Social Network Analysis for Evaluating Development Interventions: A Methods Note

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A-to-Z Guide to Using Social Network Analysis in the Development Sector

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Title	**Social Network Analysis for Evaluating Development Interventions: A Methods Note**
Purpose	This Methods Note offers easy how-to guidance to inform, educate and deepen appreciation and understanding of SNA as a tool for evaluating development interventions. It aims to inform the revision of the CGIAR-wide Evaluation Framework and on evaluating Quality of Science [see hub].
Audience	The primary audience for this document includes evaluation managers, and commissioners involved in evaluation activities within CGIAR, and beyond. Young and emerging evaluators
Framework and Policy Reference	This methods note supports operationalizing the CGIAR-wide Evaluation Framework and Evaluation Policy (2022)
Soliciting Input and Feedback	The IAES, as a custodian of this Methods Notes, welcomes queries and feedback. Users in CGIAR and beyond are encouraged to contact the Evaluation Function within the Independent Advisory and Evaluation Service (IAES) of CGIAR.
Contact	IAES-Evaluations@cgiar.org

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AR4D	Agricultural Research for Development
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIAT	The International Center for Tropical Agriculture (now part of the Alliance of Bioversity International and CIAT)
CIP	International Potato Center
CRP	CGIAR Research Program
CSA	Climate-Smart Agriculture
CSO	Civil Society Organization
DE	Developmental Evaluation
GENSA	Gender and Equity Network South Asia
GLDC	Grain Legumes and Dryland Cereals
HPAI	Highly Pathogenic Avian Influenza
IAES	CGIAR Independent Advisory and Evaluation Service
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICTs	Information and Communication Technologies
IITA	International Institute of Tropical Agriculture
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
M&E	Monitoring and Evaluation
MCH	Maternal and Child Health
NARS	National Agricultural Research (and extension) Systems
NGO	Non-Governmental Organization
PGRFA	Plant Genetic Resources for Food and Agriculture
QoR4D	Quality of Research for Development
QoS	Quality of Science
R4D	Research for Development
RTB	Roots, Tubers, and Bananas
SDG	Sustainable Development Goal
SNA	Social Network Analysis
UNICEF	United Nations International Children's Emergency Fund
WASH	Water and Sanitation Health
WHO	World Health Organization

Introduction

This Social Network Analysis (SNA) methods note focuses on key concepts around SNA and applications in the development sector, especially in the research-for-development[1]. The document offers easy-to-comprehend guidance which aims to inform, educate and deepen understanding of SNA as a tool for evaluating development interventions. The main **objectives** of this methods note are:

- To introduce and define SNA; and to understand its applications in the social sciences and evaluations;
- To develop basic skills to conduct the SNA, working with an SNA expert. [2]
- To inform the necessary steps to conduct SNA in evaluations, from data collection to interpretation; through illustrating case studies;
- To discuss potential applications in the field of development evaluation and R4D specifically;
- To help evaluation professionals and young evaluators learn to complement, supplement and navigate the challenges of implementing the SNA methodology; and

1 What is Social Network Analysis?

Any strategy for community-driven development places significant importance on social ties, considering them as valuable assets (Mathie & Cunningham, 2003, p. 479). The connections between individuals and organizations are crucial for the exchange of knowledge and resources, as well as for the facilitation of collective action towards transformation.

Social network analysis (SNA) is a method employed to examine these relations among the actors of social networks, which might include individuals, institutions, geographical sites, or items (Serrat, 2017). It is the study of relations of social structures through the application of networks and graph theory. It defines networked structures as consisting of connected nodes, which represent entities (people, organizations, devices). SNA is widely utilized in several sectors to analyze patterns of behavior, interactions and connections, the diffusion and flow of information and activities, and to monitor and forecast the success of treatments or initiatives (Lizardo & Jilbert, 2020).

The utilization of SNA as an approach in the evaluation of development interventions and initiatives is beneficial as it facilitates investigating the interrelationships among different entities, stakeholders, and/or events. SNA can also facilitate evaluation of how a network evolves over time, allowing practitioners to adjust their strategies based on the shifting dynamics and emerging trends within the network.

A social network consists of a set of entities, commonly known as nodes, that are connected by one or more relationships (Scott & Carrington, 2011). Relationships, or the connections and associations between persons, groups, or organizations, involve patterns of communication, interaction, and the movement of information. It is within the scope of SNA to identify, analyze and examine these relationships in greater

[1] For CGIAR context, this methods note can be used to operationalizes CGIAR's evaluation framework and contribute to evaluating Quality of Science (QoS) for sustainable development [QoS portal],

[2] Conducting SNA requires specific set of expertise, and it is advisable that it is done under the supervision of an SNA expert only. This document provides only a preliminary set of Information on the approach, how to collect necessary data, and basic set of precautions to be taken while conducting SNA.

detail. SNA has broad applicability across various disciplines such as sociology, psychology, anthropology, political science, business, and public health. It provides valuable information and direction in these areas (Lawlor & Neal, 2016; Neal & Neal, 2017; Valente et al., 2015; Varda, 2011) and enables discovering underlying patterns of stakeholder behavior that may be overlooked by using traditional social-scientific research methods (Yun, et. al., 2016).

Practitioners can use SNA to assess the overall structure of their networks, enhance partnerships with other community collaborators, and monitor network performance (Kothari et al., 2014). The approach also enables monitoring results, actions, the propagation of initiatives, knowledge, and available resources across a network, thereby providing valuable insights for policy or program execution (Valente et al., 2015).

In general, SNA offers a powerful instrument for comprehending the social configuration of connections and communication patterns among individuals, groups, or organizations. By comprehending networks and their capabilities, as well as possible gaps, deeper knowledge can be gained into the various aspects that impact the health and welfare of the individuals and their communities. At the programmatic end, SNA provides a wealth of information to determine the course of action of a project or initiative, and supplements the data collected on the ground or by other means, to guide on effectiveness of an intervention. For example, SNA has been used for stakeholder analysis (Prell, Klaus & Reed, 2009) for natural resource management, to examine and guide decision making processes in cases of health interventions (Kothari. et. al., 2014; Wonodi, et. al., 2012; Jolly, Muth, Wylie & Potterat, 2001). SNA can also be used to assess group cohesion and increase efficiency of teams/organizations (Flemington, Loughead & Desrosier, 2023) and even to measure the community resilience and design interventions for natural disaster management (Cui & LI, 2019).

2 Application of SNA in Evaluation

Networks are a vital concept in the field of social capital, and therefore, a significant idea in the realm of development and evaluation. Scholars, including Bourdieu (1986), Putnam (2000), and (Ricciardi 2015), argue that networks provide the structural foundation for building social capital, which is essential for development and change initiatives, including enhancing livelihood opportunities, access to resources, and strengthening community resilience.

Social workers and community development practitioners are knowledgeable of the notion of networks, as discussed by Davies (2009), Gretchen & Deborah (2010), Ennis & West (2010) & Hill (2022). Venn diagrams, genograms, and ecomaps are commonly employed in development practice to visually depict the connections among individuals, small groups, and their underlying dynamics. Community development often uses network concepts and metaphors but rarely utilizes formal social network analysis tools to conceptualize, visualize, and evaluate networks within community development models and strategies. This led to a somewhat random and disorganized implementation of network concept in the field of development and evaluation. This manual tries to fulfil this implementation gap by systematizing the main elements needed to implement SNA within an evaluative framework, especially in relation to development interventions.

In the context of social network theory, social structure refers to a network composed of social ties or relationships (Doreian, 2006). A social network is a social structure composed of actors, often known as nodes or points, and ties, referred to as the linkages or relationships. An actor is typically an individual; however, it can also refer to an organization, a country, a community, or any other clearly defined entity. A tie signifies a connection between the actors. Various types of formal and informal interactions, such as trust, referral, economic exchange, collaboration, or friendship can be depicted as networked social structures. A social network can thus be created depicting a structured arrangement of connections between various entities. These networks however can vary in size and scale, ranging from small networks such as trust connections within a small family group, to big networks such as a citywide community and welfare services client referral network.

A number of network metrics can be used to understand and study a particular network, which will be discussed in detail in later stages in this guide. However, four fundamental characteristics of social networks (Wasserman & Faust, 1994; Borgatti, Everett & Johnson, 2018; Scott, 2017) that aid in comprehending these networks include:

1. The **network's structure** refers to the way actors (individuals or entities) and their connections or relationships are organized within a network. It describes how individuals/entities are arranged and how they are connected to each other, forming the underlying topology of a network. It encompasses various factors such as the size of the individuals/entities in the network, the relationships/interactions between them, the size of the network Itself, the level of connectivity among actors, the concentration or dispersion of actors, the accessibility of the network, the degree of clustering within the network, and the heterogeneity or homogeneity of actors. The structure dictates how information, resources, and influence spread across the network.
2. **Network flows** encompass the movement of, for example, information, knowledge, data, opinions, resources or influence through the network. It is concerned with how tangible or intangible entities travel across a network. Network flows help to understand how efficiently information or resources are transmitted within a network.
3. The **network's function** highlights the goal/purpose and/or role in serving both the individuals inside it and the broader social functions, such as collaborations and socialization. Understanding the function of a network helps identify its goals and how it meets the needs of its members. It also reveals why certain networks are more successful at achieving specific objectives, such as disseminating information, mobilizing support, or fostering collaboration.
4. **Typology of the network** refers to the classification of social networks based on their structural features and the relationships between different actors, individuals and/or entities. Networks can be categorized in several ways, based on how they are organized and the nature of connections. Some common examples of types of networks include *personal networks, professional networks, ego-centric networks, online networks* such as ***Facebook*** and ***LinkedIn.*** The typology of a network helps define the relationships that exist within it and the role it plays in broader social systems. Understanding the typology can inform strategies for communication, influence, and engagement, depending on the type of network.

2.1 Importance of Using SNA in Developmental Evaluation

In an era where development initiatives strive for effectiveness, efficiency, and sustainability, the integration of SNA into methods underscoring evaluative frameworks has emerged as a powerful tool. Developmental Evaluation (DE) as an evaluative approach focuses on supporting the development of innovative programs or initiatives in complex dynamic environments[3]. DE adapts to the evolving needs and context of the program or intervention it is evaluating and suggests continuous learning. The collaborative approach of DE involves engaging stakeholders in a participative manner, valuing multiple perspectives,

[3] https://www.betterevaluation.org/methods-approaches/approaches/developmental-evaluation

and actively including program personnel, funders, beneficiaries, and other relevant stakeholders throughout the evaluation process. Systems Thinking propagated by DE acknowledges that interventions are part of bigger systems and examines relationships, feedback loops, and unintended consequences to provide information for decision-making and strategy development. Utilization-focus emphasizes that DE prioritizes utilization of evaluation findings to inform decision-making and improve program effectiveness and emphasizes the practical application of evaluation insights and recommendations, to make sure that they are relevant and actionable for stakeholders. Additionally, a context-sensitive DE acknowledges the importance of context in shaping program outcomes and effectiveness, and considers cultural, social, economic, and political factors that may influence program implementation and impact, tailoring evaluation approaches accordingly. Thus, DE is an excellent fit for programs involving uncertainty, systems change, and complexity.

SNA *as a methodology examines social relationships, encompassing links among individuals, institutions, locations, or objects. An SNA study delves into social structures by utilizing networks and graph theory, which define these structures as interconnected nodes that reflect entities such as individuals or organizations. The power of SNA lies in its ability to map, visualize, and analyze relationships and interactions within a network.*

Integration of SNA into the field of DE is based upon two key tenets-one is its participatory approach and the second is its ability to visualize relationships. Participatory methodologies and SNA techniques can indeed be seamlessly integrated to empower stakeholders throughout the evaluation process. Unlike traditional methods, SNA seeks involvement of stakeholders in the evaluation process, thereby fostering ownership, engagement, and trust. Combining participatory methodologies with SNA techniques entails involving stakeholders in research or evaluation stages through workshops, focus groups, or interviews, while also identifying key stakeholders and their relationships within the network. This fosters a sense of ownership and empowerment among stakeholders. Secondly, SNA helps to visualize relationships through graphical representations of connections, highlighting key players, flows of information and communication patterns existing within a given network. Integrating participatory methods with SNA combines qualitative insights from discussions with stakeholders and quantitative data about network structure, providing a comprehensive understanding of network dynamics. Moreover, solutions are co-created through the integration of SNA, enabling stakeholders to identify key actors within the network and develop targeted interventions or strategies that leverage existing relationships and foster collaboration. Thus, utilization of SNA as a research approach in DE is beneficial as it facilitates investigating the interrelationships among different entities, stakeholders, and/or events in a holistic and innovative manner.

Since SNA helps us to explore network dynamics by analyzing patterns of behavior, interactions and connections, diffusion of information and activities, and to monitor and forecast the success of treatments or initiatives, an increase in the number of development projects conducted through partnerships and coalitions has rightly accentuated the need for using SNA. SNA can be used as a diagnostic tool during situational analysis of a project/program design. Using SNA, an existing plan can be analyzed, a strategy to support an existing network can be created, or new network can be built. The program or project can then be monitored and assessed using standard Monitoring and Evaluation (M&E) methods.

An SNA exercise can be undertaken to assess changes over time and monitor the implementation of a project or a program. Though application of SNA requires an elaborate process for program monitoring, especially in development context where passive SNA data is hard to obtain, SNA can still be used to track stakeholder relationships, intervene, improve, and facilitate implementation of projects requiring intersectoral partnerships. Lastly, and most commonly, SNA is used as an evaluation tool, as it can reveal insights into how individuals within a group, community or network collaborate, identify areas where relationships can be enhanced or developed, especially in cases where network performance affects the success of a group or organization. An SNA study can reveal insights into how individuals within a group collaborate and can identify areas for development where relationships can be enhanced or developed, especially when the network's performance affects the group's success.

When used as an evaluation tool, whether in the planning stage or afterwards for evaluation of impact of a project/program or intervention, SNA can assist in addressing the following inquiries:

- Who is linked to whom?
- What is the effectiveness of current relationships?
- To what extent are various sectors interconnected in the network?
- What is the strength of these connections?
- Are these relationships directional?
- Who are the main participants[4] and who are the outliers or passive ones?
- Where should relationships be established and/or which ones should be strengthened?
- How is power distributed in the network?
- Who shares resources with whom and of what type?

At the programmatic end, SNA provides a wealth of information to determine the course of action of a project or initiative, and supplements the data collected on the ground, to guide effectiveness of an intervention. From this perspective, the advantages of using SNA in DE lie in its ability to capture changes over time, allowing for ongoing adaptation and refinement of strategies, and identifying influential individuals or groups who can catalyze or impede progress within an initiative. SNA is widely used to map and analyze knowledge networks and communities of practice. As it is evident that attaining significant and long-lasting improvements at different levels requires an intersectoral approach that recognizes presence and use of the many factors and players. SNA can help describe the intersectoral collaboration between the organizations that focus for example, water and sanitation health (WASH) issues such as maternal and child health (MCH), environment, and education. Within the development sector, various non-governmental organizations (NGOs) & civil society organizations (CSOs) employ SNA for mobilization purposes and for influencing policy (Valente et al., 2015).

For example, in a country with high rates of child malnutrition, a coalition of NGOs and CSOs focusing on nutrition, healthcare, and education may use SNA to influence national health and education policy. By mapping connections between local healthcare providers, educational institutions, international donors, and government health departments, the coalition can identify key nodes (decision-makers, funding bodies) and weak links (areas with minimal intervention or support). They can then mobilize resources, build new partnerships, and target specific policymakers to advocate for better school nutrition programs, ultimately pushing for policy change.

[4] In SNA, main participants refer to participants with high centrality, i.e., participants with high influence and interests (either supporting or opposing) the change.

2.2 Key Concepts of SNA

A social network is a social structure consisting of a group of players, such as individuals or organizations, and the connections they share. In the development context, if often refers to a socio-political and socio-economic ecosystem. The concept of a social structure being represented as a network allows for a more comprehensive understanding and examination of this socio-economic-politico structure. This includes the ability to identify both local and global traits, influential actors, and the dynamics of the relationships For instance, using SNA to comprehend an inter-organizational network, various development organizations can be identified, such as NGOs, CSOs, multilateral organizations such as United Nations International Children's Emergency Fund (UNICEF) and the World Health Organization (WHO), and can also enlist the various forms of interaction such as communication and collaboration. Thus, these development organizations are called nodes and the types of interactions/linkages between the different nodes are often called edges.

The table below lists some of the key attributes[5] of SNA, their definitions and their applications.

Table 1. Key attributes of SNA

Attributes	Definition	Applications for M&E
Nodes	Nodes represent individuals, groups, communities, organizations, or other entities within a network, e.g., the different types of organizations (say internal partners, external partners, donors) working together on a project are the nodes.	Identify the key actors and players in each network.
Edges	Represent different ties/links/relationships/ interactions between nodes. Edges are the relationships present like friendships, collaborations, or communication ties between individuals/groups, communities or organizations within a given network.	Help to define the type and nature of linkage/communications existing within a network.
Sociogram	Represents a visualization with defined boundaries of connections in the network (For illustration please see Figures 1, 2 ,3 and 4 in section 3 of this document).	Help to depict various attributes and centrality measures.
Directed/Undirected Network	In undirected networks, the edges connect unordered pairs of nodes, i.e., each edge of the graph connects concomitantly two vertices, e.g., a network of organizations working together on a common goal, such as a consortium of NGOs implementing a joint program. In directed networks, all edges have an orientation assigned, so the order of the vertices they link matters. Directed networks represent relationships where the connection between two nodes has a specific direction (e.g., Twitter), while undirected networks represent relationships where the connection is bidirectional (e.g. Facebook friendships).	Helps identify the type of network and the type of connections and direction of those relations, whether the connection is one-way or two-way.

[5] Some of the basic attributes to understand terminology of SNA for a beginner are added. For further reading, please see Wasserman & Faust (1994); Knok & Yang (2008); Oliveira & Gama (2012); Bonnet et. al. (2023).

Attributes	Definition	Applications for M&E
Ego Network	Ego-centric networks comprise a focal node ("ego") and the nodes to whom it is directly connected to ("alters") plus the ties, if any, among the alters.	Indicates how well an individual (ego) is connected to others (alters) & how those other individuals (alters) are connected to each other. Helps in understanding position of a key stakeholder and the network of relationships around that stakeholder.
One-Mode /Bipartite Networks	In one-mode networks, the set of nodes that are similar to each other (e.g., participants in a project). Bipartite networks have two different sets of nodes, and ties exist only between nodes belonging to different sets. In other words, the nodes in one set are connected to nodes in the other set, but there are no edges between nodes within the same set. (e.g., participants in a project and project activities; students and courses).	Helps decode social networks from different angles/perspectives, allowing analysis at different levels – right from individual relationships to group dynamics to even comprehending interactions between different types of entities.

2.3 Tools and Skills

There are several tools for visualizing social network graphs. However, while software can support the application of SNA, understanding the foundations of the approach, both as a theoretical framework and an applied methodology, are essential for the appropriate use of these tools and for the correct interpretation of results.

Here some of the most used paid and open-source software and tools are presented. Some require extensive knowledge of graph theory or experience with programming, while others present user interfaces that guide analysts through the available features.

Table 2. Software and tools

Tool	Description	Operating System	Open Source	Link
GEPHI	Open-source network analysis and visualization software for exploratory data analysis.	Windows, macOS, Linux	Yes	https://gephi.org
UCINET	Comprehensive software package for social network analysis with visualization tools.	Windows	No (Paid)	http://www.analytictech.com/archive/ucinet.htm
PAJEK	Software package for network analysis and visualization with advanced algorithms.	Windows	No (Freeware for non-commercial use)	http://mrvar.fdv.uni-lj.si/pajek/
NETWORKX	Python library for creation, manipulation, and study of complex networks.	Windows, macOS, Linux	Yes	https://networkx.org

Tool	Description	Operating System	Open Source	Link
DATAMUSE[6] network analysis application	Cloud-based participatory network mapping and analysis application.	Cloud based application	No (Paid)	https://datamuse.io/network/login.php
KUMU	Cloud based network mapping tool.	Cloud based application	No (Paid)	Kumu.io
NODEXL	Excel add-in for network analysis and visualization with tools for importing data.	Windows	No (Free version available, paid Pro version)	https://nodexl.com
IGRAPH	Library for network analysis and visualization available in R and Python.	Windows, macOS, Linux	Yes	https://igraph.org
SNAP	High-performance system for analysis and manipulation of large networks.	Windows, macOS, Linux	Yes	http://snap.stanford.edu
VISONE	Software tool for network analysis and visualization with advanced visualization techniques.	Windows, macOS, Linux	No (Freeware for non-commercial use)	https://visone.ethz.ch
SOCIAL NETWORK VISUALIZER	Cross-platform application for social network analysis and visualization specifically targeted for the social researcher.	Windows, macOS, Linux	Yes	https://socnetv.org

2.4 Step by Step Guide to SNA for Development Evaluation

Ideally, SNA should be incorporated into the design stage of a project or program, so that a baseline of interactions and relational dynamics is created, and network concepts are embedded in the intervention itself. Subsequent evaluations can then objectively assess the evolution of these interactions.

However, if SNA was not integrated into project design, it can still be implemented for a posteriori evaluation. This section highlights some of the key steps in applying SNA to evaluate an intervention.

2.4.1 Evaluability Assessment for using SNA

To collect data that can be analyzed through SNA, evaluators must first decide what kinds of relations they wish to assess – i.e., the objective of the evaluation. Some key questions to consider include:

[6] Conflict of Interest disclosure: 'This network analysis software has been developed by Mr. Amitaksha Nag and his team at Datamuse, which is frequently used by CGAIR, World Bank, USAID, and many development programs. There are many examples in public domain that are available if required. It is ranked as one of the most accessible SNA applications by WRI, see page 60 of this report https://www.folur.org/sites/default/files/2022-03/18_Guide_SocialMapping_FINAL3.pdf.

- Is the evaluation assessing the effectiveness of collaborative efforts, identifying key collaborators, or understanding collaboration patterns within a broader network?
- Is the unit of analysis a person, a group, an institution, or are these entities mixed? Who is or is not part of the network?
- Is the objective to study all nodes (whole network data) or a network around a particular node (ego network data)?
- Are the social ties directed (they go from one node to another) or undirected (ties between nodes exist with no particular direction)?

The questions above help define the boundaries of the intended network, determine the relations to be studied, and identify the appropriate sampling method. Essentially, a clear research strategy should be established prior to data collection, so that the criteria for analysis and the parameters of social relations can be determined.

2.4.2 Collecting Data

Network data can be collected through observation, from institutional archives, from digital traces, and through primary data collection.

In the case of primary data collection through surveys and interviews, social network data can be collected by asking respondents to report with whom they share relations. For example, a survey can present a list of network members and ask respondents to indicate those with whom they share ties. If making a list is unfeasible, respondents can be asked to recall people or entities with whom they share a relevant connection (snowball sampling technique). To establish the strength of these relationships, respondents can be asked to rank their connections by importance. For example, a survey gathering data on the relationships, communications, and collaboration among individuals, external partners, donors or commissioners involved in a project, can include questions not only about the basic demographic profile, but can also include questions on relationships and interaction mapping-listing all individuals and organizations (names or roles) that a respondent communicates with regularly for project-related work, rank them in order to approachability and describe overall collaboration with the following groups or individuals/organizations on a scale of one to five).

Group-based participatory and mixed methods approaches are also used to collect both quantitative network and qualitative data analysis (The World Bank Group, 2016).

2.4.3 Processing the Data and Constructing a Network

After cleaning the results from the data collection, the information needs to be converted into a suitable structure for network analysis, such as an edge list or an adjacency matrix.

An edge list is a way to structure the data by listing the connections in a two-column matrix, where the first column contains the source node, and the second column contains the target node, i.e., the start and end of an edge. If the strength of a connection is known, a third column can be added to present this information as the weight of the edge. An example of an edge list is shown in Table 3 below.

Table 3. Example of weighted wdge list

Source	Target	Weight
Actor 1	Actor 2	5
Actor 1	Actor 3	2

Source	Target	Weight
Actor 2	Actor 1	2
Actor 2	Actor 4	3

The adjacency matrix lists all entities in the network in rows and columns and indicates when two entities share a relationship with a value, which can be binary if no weights are attributed to the connection. An example is provided in Table 4 below.

Table 4. Example of weighted adjacency list

	Actor 1	Actor 2	Actor 3
Actor 1	0	1	3
Actor 2	1	0	1
Actor 3	3	5	0
Actor 4	3	2	1

Once nodes and edges are defined and structured, network analysis software should be employed to construct a network graph. Using the features available in the chosen software, visualizations can depict the structure and dynamics of the network.

2.4.4 Analyzing a Network

There are several possible analyses once a network graph has been constructed. These include:

- Descriptive analysis: Calculation of network metrics such as density, clustering coefficients, and centrality to describe a network's characteristics mentioned earlier in the note (see page 18).
- Identifying key entities: Centrality measures identify entities with significant influence within a network, such as actors with a high number of direct connections (degree centrality) or those that serve as bridges between different parts of the network (betweenness centrality).
- Identifying clusters or communities: Community detection algorithms identify clusters or sub-groups of nodes with stronger ties among themselves than in relation to the rest of the network.
- Evaluating network evolution over time: When data is time sensitive, it is possible to generate dynamic graphs that assess how patterns evolve over time, considering factors like network growth, stability, or changes in behavior.

The table below summarizes some of the possible analytical concepts.

Table 5. Possible analytical concepts

Concept	Definition	Applications For M&E
Geodesic Distance	The number of relations in shortest path between two nodes.	Indicates the closeness between nodes in a network.
Network Diameter	The longest distance among the shortest paths between any two nodes - i.e., the largest geodesic distance.	Indicates a network's size by calculating the number of nodes it takes to get from one side to the other.
Reciprocity	A measure of the likelihood that nodes in a directed network are mutually linked.	Indicates the level of interchange between nodes.
Density	Represents the level of connectivity between nodes/actors/participants.	Quantifies how many of the possible connections in a given network are present

Concept	Definition	Applications For M&E
		and how close participants are within the network.
Centrality	Focuses on the behavior of individual nodes/ participants within a network.	Measures the extent to which an individual interacts with other individuals in the network. Used to determine the importance of an individual or entity in a social network.
Degree Centrality	Represents the number of direct hops or the shortest path between two entities in a network.	Characterizes the structure of networks, indicates power and influence. The higher the connections, the greater their degree centrality measures.
Closeness Centrality	Depicts the average of the shortest path length from one node to every other node in the network.	Measures how central a node is in their network, indicating its closeness to all the other nodes of the network.
Betweenness Centrality	Quantifies the number of times a node acts as a bridge along the shortest path between two other nodes.	Used to identify individuals/actors who act as a ' bridge' in a network.
Eigenvector Centrality	Depicts the nodes/actors that are connected to highly connected nodes/actors.	Measures transitive influence of nodes in a given network by identifying which actors/nodes are connected to other popular/influential nodes/actors.
Clustering Coefficient	Depicts the number of closed triplets in the node's neighborhood over the total number of triplets in the neighborhood.	Useful in grouping objects (e.g., products, respondents, or other entities) in a network based on a set of user selected characteristics or attributes.
Network Spatialization	The distribution of nodes across a network graph. Force-directed algorithms simulate attractive forces between connected nodes and repulsive forces between all nodes, resulting in a balanced layout.	Enables comprehension of network dynamics, the role of central nodes and study strength of relationships.
Modularity	Determines the level of homogeneity within a network by identifying communities comprising groups of nodes that interact more frequently with each other than they do with others.	Enables identification of communities or clusters of interaction.

2.4.5 Interpreting the Results

Adequate interpretation of a sociogram is challenging, as it requires a nuanced understanding of the structural and relational dynamics within a community or organization. Evaluators must thoroughly understand the context under which the network was devised and be aware of the sensitivities associated with the results.

Drawing back to the objectives of the evaluation, the analysis of the network's structure and key metrics enables describing and understanding patterns of connectivity within a network. For instance, the density of the network reflects the extent of connections within nodes, indicating how interconnected the individuals or groups are. High density can suggest strong collaboration and communication, which are vital for the success of development interventions. Centrality measures, such as degree centrality, betweenness centrality, and eigenvector centrality, help identify influential actors within the network. Such actors can be pivotal in disseminating information, mobilizing resources, and fostering community engagement.

Spatialization of nodes and community detection provide further insights into strengths, weaknesses and gaps within the network structure. Analyzing clusters within a network can provide insights into the existence of sub-communities that may impact an intervention's dynamics, such as alliances, divisions or marginalized groups. It is also crucial to assess the strength and quality of ties between nodes, as strong, trust-based relationships are more likely to facilitate effective collaboration and information exchange.

Practical implications of these findings should be discussed in terms of achieving outcomes expected from a given intervention, project or program. Importantly, interpreting the results involves contextualizing the findings within the broader socio-cultural, economic, and political environment of the intervention, as external factors can influence outcomes.

3 Case Studies

CGAIR organizations continue to apply SNA in diverse contexts for assessments and evaluations, such as evaluating organizational networks for the effectiveness of the CGAIR Genebank, the diffusion of rural innovations (Ira Matuschke, 2008), policy change for surveillance and control of Highly Pathogenic Avian Influenza (HPAI) in Ghana (Eva Schiffer, Clare Narrod, and Klaus von Grebmer, IFPRI), gauging the influence of CGAIR climate research programs, adoption of modern crop varieties (IFPRI Discussion Paper, 2020), evaluating Science groups, for transforming Agrifood systems and in case of disaster-related resettlements (an external case). Below are few case studies illustrating some of CGAIR's work using SNA.

3.2Using SNA to Evaluate the Relevance and Effectiveness of CGIAR Genebank Platform

Read the full study:

- Anand et. al. (2023). **Evaluation of the CGIAR Genebank Platform: Social Network Analysis.** IAES CGIAR (Independent Advisory and Evaluation Service), IAES Evaluation Function.
- Humphrey et al. (2023). **Evaluation of the CGIAR Genebank Platform, Report.**: IAES Evaluation Function.

The CGIAR Genebank Platform was an essential component of a global system on the conservation and use of plant genetic resources for food and agriculture (PGRFA). It was a program that supported the day-to-day operations of genebanks to encourage use of modern technologies, ensuring access to crop and tree diversity along with ensuring that all genebanks comply with international standards and policies. Led by the Crop Trust, the CGIAR Genebank Platform enabled all 11 CGIAR genebanks to fulfil their legal obligation to conserve and make available accessions of crops and trees on behalf of the global community under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

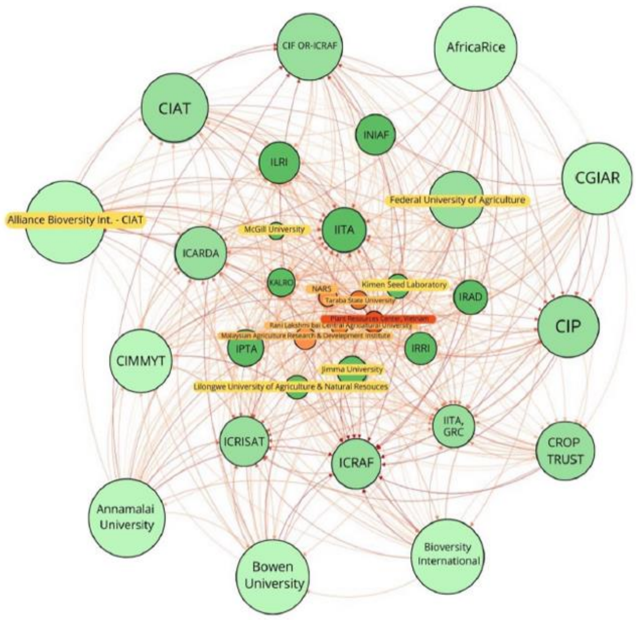
In 2023, an evaluation of CGIAR Genebank Platform was carried out to support the institutional learning of CGIAR and the Crop Trust and provide evidence on the efficiency and effectiveness of the Genebank Platform (from 2017-21). SNA was part of the 2023 Genebank Platform evaluation.

The key objectives of the evaluation included identifying good practices and lessons for the Genebanks Initiative, the Genetic Innovation Science Group and CGIAR more broadly. The evaluation approach and data collection followed a mixed-methods design, leveraging both qualitative and quantitative data from primary and secondary sources to answer evaluation questions, understand operating environments, and track contextual and programmatic assumptions.

The SNA aimed to identify and delineate the main stakeholders and study the relationships between themselves and other stakeholders as they interacted on CGIAR's Genebank Platform. The analysis focused on comprehending the flows of information between these different partners and users. Filtering and cleaning data from the responses received to an evaluation survey eventually led to a subset of responses that were processed, along with subsequent matrices indicating the ties and other network characteristics analyzed using Gephi, an open-source software. The Fruchterman Reingold algorithm (Bi, Wang, Zhao, Qi & Zhang, 2018) was used to show the spatialization of nodes, as this visualization disposes nodes in a gravitational way (and this helps to distinguish communities). This was followed by Force Atlas 2 to disperse groups and give space around larger nodes. Noverlap, a repulsion force to prevent node overlap, was also used.

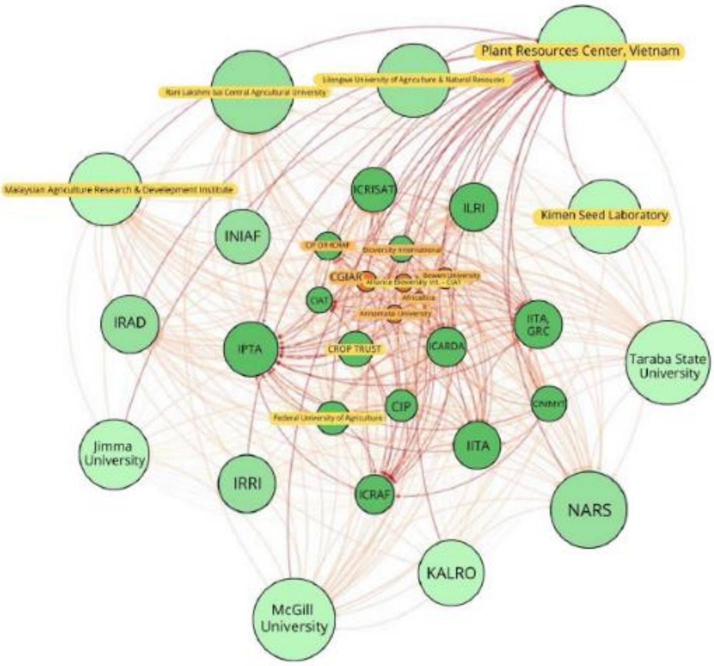
Four clear-cut network graphs, namely, professional network, communications and interaction pattern graphs (Figure 1), and graphs showcasing the network of nodes for leadership, and management decision-making and funding needs (Figure 2)—were obtained from the data. Key clusters were identified, with emerging networks showing moderate network density (0.5), implying that the network of partners and users interacting over the Genebank Platform was moderately connected. Various centrality measures pointed to the significance of each node within a given social network and provided insights into the role that these nodes can play in improving the efficiency of the Genebank Platform.

Figure 1. Communication patterns and interactions between nodes or partners on the Genebank Platform



The use of SNA in the evaluation study complemented and supplemented the three key criteria of relevance, effectiveness and coherence, and aided results obtained for the other three modules, namely, policy, conservation, and use. The findings revealed that National Agricultural Research (and extension) Systems (NARS) and non-CGIAR partners, such as Taraba State University (Nigeria) and the University of Cambridge (England), with the most incoming connections, were the most appropriate key collaborators for extending the on-the-ground reach of CGIAR and the Genebank Platform. Furthermore, the results identified those partners with the most external linkages as having the potential to act as potential 'broadcasters' of information and innovation. Key takeaways from use of SNA included the need for CGIAR to continue its efforts to strengthen its relationship with the NARS in each country. Triangulation of data from other modules, along with the use of SNA analysis, revealed that though the professional network of the Genebank Platform had CGIAR partner organizations—namely, Alliance Bioversity International (CIAT), the International Institute of Tropical Agriculture (IITA), the International Potato Centre (CIP), CIFOR-ICRAF and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)—playing important roles in the conservation and policy modules, non-CGIAR partners had the potential to play a crucial role in meeting the requirements of the use module. They also have the potential to be pivotal in meeting the needs of farmers and other user groups in time and in ensuring that farmers and other user groups, whose focus is to enhance the conservation and use of genetic diversity in situ, are dealt with effectively. Thus, the Genebank Platform acted as a hub where the exchange of information about core collections took place.

Figure 2. Network of organizations illustrating funding-related communication and information flows



SNA also revealed that, while the CGIAR partners could act as important broadcasters of information on access and availability of plant genetic material and accessions, the non-CGIAR partner network could be leveraged to expand CGIAR's existing network with end users (farmers and community-based organizations). These non-CGIAR partners, especially NARS and academic and research institutions, act as anchor points for region-specific subgroups of users when accessing relevant information on plant and crop diversity and their conservation. This will enable CGIAR to meet its objective of enhancing the reach and timely accessibility of germplasm by ultimate user groups (i.e., farmers). Moreover, utilizing the broadcasting potential of nodes with high degrees of centrality will ensure the cost-effectiveness of future interventions. The strategic establishment of a hierarchy to empower local and influential partners could help to further empower these partners and motivate them to build the network and implement projects independently at ground level, thereby increasing overall effectiveness.

3.3 The Use of SNA to Assess Influence and Reach of Climate Research Programs

Read the full study:

- Carneiro et al. (2020). **A web analytics approach to map the influence and reach of CCAFS** *CCAFS Working Paper no. 326.* CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).
- Carneiro et al. (2022) **What is the importance of climate research? An innovative web-based approach to assess the influence and reach of climate research programs**, *Environmental Science & Policy*, 133:115-126.

This evaluation sought to understand the influence of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) in motivating actors to tackle climate change. In the CCAFS theory of change[7], a cross-cutting aim was to work with strategic partners to "foster policy and institutional change" that will enable large-scale Climate-Smart Agriculture (CSA) adoption. The thematic area on Priorities and Policies for CSA (Flagship Program 1) facilitated this outcome, and progress monitoring included reporting the number of policies and investments informed by CCAFS research. However, this indicator did not capture the full extent of CCAFS' influence, as it did not consider the 'soft power' processes that enable policy or investment decision-making, such as shaping perceptions and gaining visibility of CSA as an attractive and viable approach to climate adaptation through improved knowledge exchanges between stakeholders involved in the policy process, increased trust between scientists and policymakers, more diverse and stronger social networks, and enhanced capacity of policymakers and their institutions.

Due to the pervasiveness of the internet in people's lives, recent academic research recognizes web and social media activities as proxies for wider public discourse and engagement. Based on this notion, the evaluation assessed the role of CCAFS in shaping perceptions and raising the visibility of CSA as a viable approach to climate adaptation by considering online narratives and relationships as grounded evidence of influence. An innovative, data-driven approach was employed to explore the dynamics of knowledge dissemination and changes in attitude towards CSA among stakeholders at various levels. Selected web sources and social media platforms were assessed through text mining, network analysis, hyperlink analysis, and query analysis. General results showed that CCAFS inspired positive change in government policy, built a global community for climate adaptation, and sparked public interest in CSA.

As an important space for climate change information-exchanges, Twitter (currently X)[8] was one of the sources for analysis. The official, public profiles of strategic CCAFS partners were mapped and their conversations extracted, both to assess the extent to which climate adaptation activities developed through CCAFS projects are represented in their conversations, but also to explore CCAFS role in driving this narrative.

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[7] Theory of change is a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context. A method that explains how a given intervention, or set of interventions, are expected to lead to a specific development change, drawing on a. causal analysis based on available evidence. (For more information, read the UNDAF Companion Guide, https://unsdg.un.org/sites/default/files/UNDG-UNDAF-Companion-Pieces-7-Theory-of-Change.pdf).

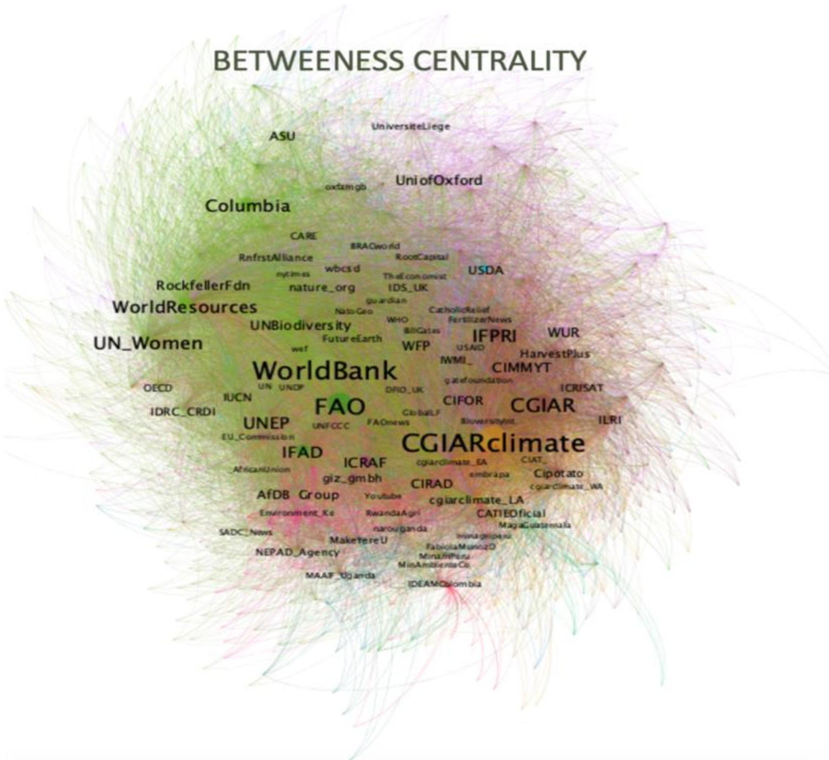
[8] Considering this research was conducted prior to the platform currently known as X's rebrand, we have preferred to maintain its original name and terminology (i.e. Twitter, tweets, etc). This is to ensure that the analysis of affordances and platform dynamics represent the context of the platform at the time of analysis.

Regarding the latter, SNA was applied to locate CCAFS within its network of strategic partners. Using the metadata collected from Twitter content disseminated by partner profiles, it was possible to assess CCAFS' position and interactions with stakeholders by analyzing the accounts mentioned in the tweets. SNA was performed to explore the relationship between @mentions in the corpus. In this case, entities are the nodes - in this case, @mentions - and their relations are the lines connecting pairs of nodes. This means that accounts are connected if they are mentioned by another.

The complete network built from almost 900 thousand tweets was very large, as more than 63 thousand accounts were mentioned by partners over the period of analysis. To identify key actors, the network was filtered for accounts mentioned at least five times. This focuses the analysis on actors that were more frequently part of the conversation exchanges between CCAFS partners, reducing the number of accounts to approximately 2,300, with 23,000 connections between them.

To allow for a visual interpretation of the dynamics between actors in the network, a force-directed algorithm was selected, and accounts were sized according to their betweenness centrality. This metric measures how much a node acts as a bridge between others in the network. According to literature that has examined the interaction between organizations and the public on Twitter profiles with high betweenness, centrality can be considered 'social mediators' and play an important role in reaching out to others that do not interact directly with that organization (Hansen et al, 2011). Moreover, actors with high betweenness centrality often connect entities from different clusters, which can influence information flow across groups.

Figure 3. Network of @mentions from CCAFS partner twitter accounts (for nodes mentioned at least five times)



The resulting visualization is presented in Figure 3. It shows some discernible clusters, with the largest ones (green and brown) containing international development institutions and large media outlets. CGIAR centers are located within the brown community. Smaller clusters include accounts from Africa and Latin America (pink and blue), and academic institutions (purple). As shown, the CCAFS account (@CGIARclimate) is positioned among key players within international development and research institutions and has an important role connecting the various actors.

Figure 4. CCAFS ego network

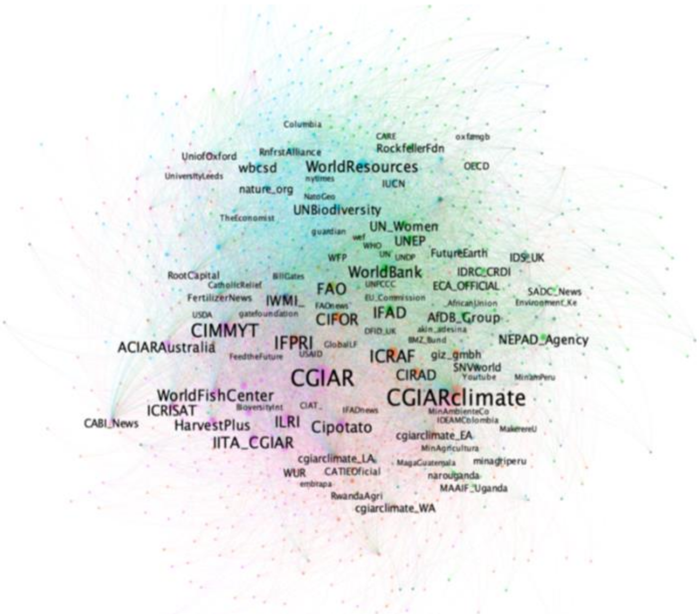


Figure 4 presents CCAFS's 'ego network', comprising 909 nodes directly connected to @CGIARclimate within the network of partner tweets. Excluding CGIAR-related accounts, the program's immediate network contains 890 nodes, which represent both Twitter accounts that CCAFS has mentioned, and those that mentioned CCAFS.

3.4 SNA in Disaster-Induced Resettlements

Read the full study:

- Faas et al. (2015). **Critical aspects of social networks in a resettlement setting.** *Development in Practice*, 25(2), 221–233.

As an external example, SNA was applied to research and policy in forced displacement and resettlement. Each year, more than 30 million people worldwide are displaced by disaster, development, and conflict. The sheer magnitude of displacement points to a need for wider application of social science theories and methodologies to the special problems posed by these crises. SNA of social relationships can reveal key variables and patterns that support or promote social (re)integration in resettlement. Faas et al. (2015) used advanced SNA methods to explore structural gaps in networks within the context of forced displacement and resettlement. The study took place in two disaster-induced resettlements in the central Andean highlands of Ecuador, following the eruptions of Mt. Tungurahua in 1999 and 2006. In response, various agencies-built resettlements for displaced families. The first, Penipe Nuevo, located in the city of Penipe, consisted of 287 new homes, built by the Ministry of Housing (MIDUVI) and Samaritan's Purse and second was a smaller resettlement, Pusuca, located six kilometers southeast, was built by the Ecuadorian

NGO Fundación Esquel and included 45 homes around a central park, with each household granted one hectare of land.

The SNA conducted in disaster-induced resettlements in highland Ecuador, following eruptions of Mt Tungurahua in 1999 and 2006. and the two resettlement sites: Penipe Nuevo, where new homes were constructed by government and NGO agencies, and Pusuca, where a local NGO built homes and granted land to each household, were studied.

The study evaluated key network principles in the context of disaster-induced resettlements to contribute to more effective resettlement and development policies. The study assessed both whole networks (connections within a group) and personal networks (connections of individuals within their own networks) in these two disaster-induced resettlements in 2009 and 2011. SNA focused on three key variables: density, bridging, and subgroup cohesion. Density referred to the number of observed ties compared to possible ties within a network. Bridging measured individuals' roles in connecting different parts of the network. Subgroup cohesion looked at the density of ties within subgroups compared to ties between subgroups and others. The aim was to understand how these network characteristics impacted collective action, information flow, and resource distribution within resettlement communities.

Findings highlighted significant differences in social network characteristics and their impact on support exchanges and community cohesion between the urban resettlement of Penipe Nuevo and the rural agricultural resettlement of Pusuca. Pre-resettlement patterns of kinship and village ties played a significant role in shaping network subgroups in the resettlements. In Penipe Nuevo, the lack of shared resources led people to rely on their kin and village-based networks for support, while in Pusuca, the availability of resources encouraged a broader network of social support beyond pre-resettlement ties. Although councils and committees were weak in Penipe Nuevo, they were stronger in Pusuca due to the resource base that supported them, fostering cohesion and informal reciprocal ties.

The study showcased that studying social relationships in resettlements is both feasible and valuable, and that ethnography and SNA complement each other, especially in resettlement contexts. SNA can help design interventions that not only provide education, training, and resources, but also foster connections that support resettles in adapting to new challenges. The study advocates for a more nuanced understanding of network structures in resettlement planning and policymaking.

Recommendations include considering network dynamics in land compensation policies and promoting inclusion of less-represented groups in decision-making processes. It recommends that efforts to foster new networks and connections should be balanced with an awareness of potential social strains and challenges to traditional patterns of reciprocity and patronage and, underscored the importance of SNA in informing interventions and policies aimed at promoting equitable resource distribution, social cohesion, and adaptive responses in resettlement contexts.

3.4 Utilizing SNA to Improve/Enhance Quality of Science

Read the full study:

- Sula et al. (2024). **What traits of collaboration networks are associated with project success? The case of two CGIAR agricultural research programs for development**, *Agricultural Systems*, *219* (Aug), 104013, ISSN 0308-521X, https://doi.org/10.1016/j.agsy.2024.104013
- Rünzel, M., Sarfatti, P., & Negroustoueva, S. (2021). **Evaluating quality of science in CGIAR research programs: Use of bibliometrics**. Outlook on Agriculture, 50(2), 130–140. https://doi.org/10.1177/00307270211024271

The CGIAR Evaluation Framework and revised Evaluation Policy are designed to meet the evolving needs outlined in the 2030 CGIAR Research and Innovation Strategy. Central to this framework is the Quality of Science (QoS) criterion, which evaluates research inputs, processes, and outputs. Evaluating QoS in development research necessitates clear criteria, especially since bibliometric indicators[9] often fail to capture the multifaceted nature of research quality. To assess QoS effectively, diverse methods and tools are required, particularly those linked to CGIAR-wide monitoring and evaluation systems.

SNA can enhance the evaluation of QoS by integrating various dimensions, such as geographical focus, gender, collaboration duration, and bibliometrics. It emphasizes the importance of collaboration in agricultural research for development (AR4D) to achieve Sustainable Development Goals (SDGs). Thus, to evaluate the QoS in development initiatives, the altmetric and bibliometric indicators were used in the 2020 review of CGIAR Research Programs (CRPs), (CRPs, 2017–2022), which for the first time was applied the Quality of Research for Development (QoR4D) framework across the entire CRP portfolio. The review found a substantial output of scientific publications from 2017 to 2020, including 4,872 articles and an average of 7.1 citations per article. Altmetric scores[10] indicated strong public interest, with attention scores ranging from 70.8 to 806.9, averaging 425.1. Bibliometric indicators thus proved useful in evaluating QoS, alongside other qualitative measures, across the 12 CRPs. The review highlighted the importance of standardized, consistent data on research output for high-quality quantitative evaluation. Integrating bibliometric indicators into the QoR4D framework as part of the new One CGIAR and supporting their use with clear guidelines for monitoring and evaluation was thus recommended.

In another study conducted by Sula et. al. (2024) an attempt was made to research how collaboration in scientific communities can significantly advance global agricultural systems that support the UN SDGs, and to analyze how collaboration patterns can improve research program structures and dynamics. Sula et. al (2024) introduced a framework for evaluating collaborative research networks based on scientific publications and their role in achieving societal goals. The framework was applied to two CRPs: Grain Legumes and Dryland Cereals (GLDC) and Roots, Tubers, and Bananas (RTB) and subsequent analysis provided insights into research team composition, management structures, and publication performance. Using network models, collaboration at the levels of authors, institutions, countries, and management structures were examined. Regression models helped identify factors influencing citation rates and Altmetric Attention Scores.

Key findings included identification of collaboration hubs in both programs, with institutional hubs typically being CGIAR program 'participants' or 'planning partners'. The study found that the proportion of women authors was under a third, with limited co-authorship between women. Research in both programs focused on priority countries, with most international collaborations occurring between institutions from

[9] Bibliometrics is the quantitative analysis of citations and content in scholarly works. The biblometric indicators are usually citation-based indicators like citation count, impact factor, H-index etc. are commonly used to assess research, but they have significant limitations and may be misused in certain contexts. (For more Information, please read Okubo, Y. Biblometric Indicators and Analysis of Research Systems: Methods and Examples, https://dx.doi.org/10.1787/208277770603).

[10] The Altmetric score is an early indicator of an article's potential impact. Altmetrics are measures of the impact of a scholarly research product based on online activity, using information beyond scholarly citations alone and are designed to capture research impact and to recognize more types of impact. While metrics like citation counts, download counts, h-index, and the impact factor show the impact of a research study in the academic interest, Altmetrics show the immediate impact of a research study in a social interest. (Read more on https://www.altmetric.com/about-us/what-are-altmetrics/).

Global South and Global North countries. The study found that teams with high geographic diversity and strong collaboration were associated with higher citations and altmetric scores. Additionally, co-authorships were often short-lived, with most occurring in a single year.

These insights into research networks guided agricultural research systems, helping program managers and funders optimize future research projects. Specifically, it pointed that the strategies should focus on gender parity, balanced international collaborations, and fostering long-term, impactful research teams for sustainable development.

Figure 5. Research network of institutions linked with the GLDC research program through authorship of journal articles published in 2018-2020

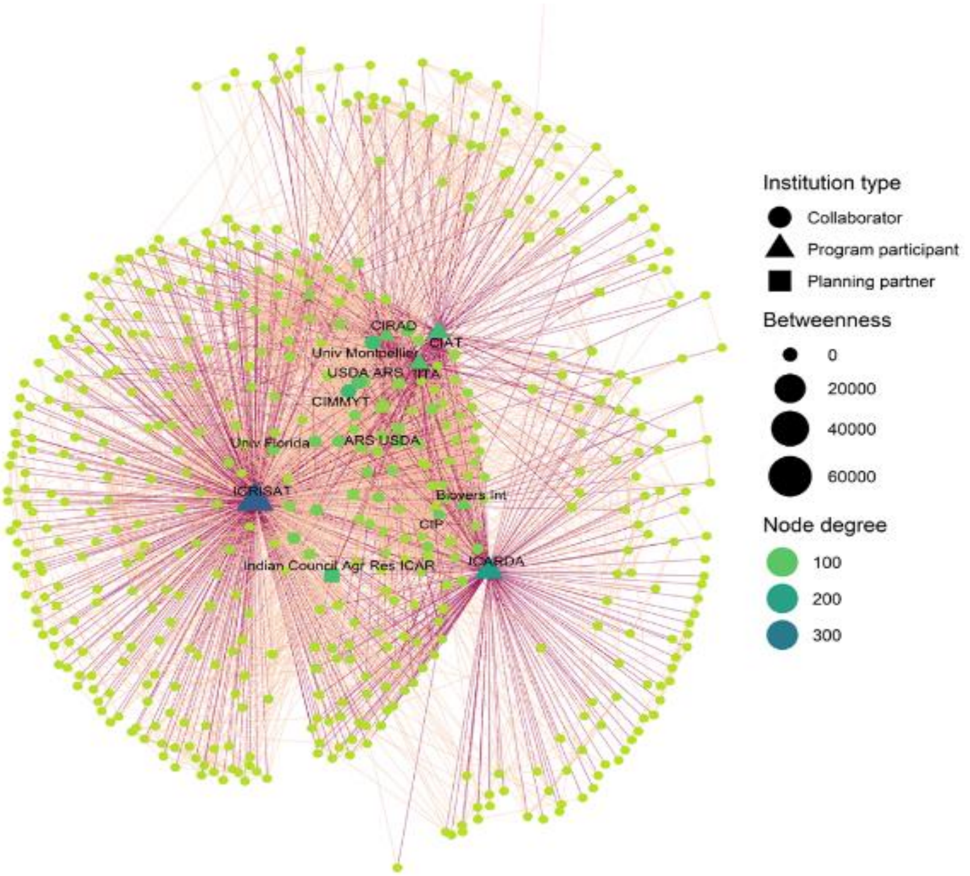


Figure. Research network of institutions linked with the GLDC research program through co-authorship of journal articles published in 2018-2020 in Phase II. Nodes represent institutions and links represent co-authorship of institution members. The darker the node color, the higher the institution node degree, meaning the institution has a higher number of connections with the other institutions in the network. The node size represents the institution betweenness centrality, which is a measure of a node's importance within the network. The institution name is included for nodes with an institution node degree greater than 75 collaborations. Darker pink links represent articles resulting from collaborations with CGIAR centers.

3.5 Using SNA in CGIAR Science Group Evaluations

Read the full studies:

- CGIAR Independent Advisory and Evaluation Service (IAES). (2024). **CGIAR Science Group Evaluations: Brief on Quality of Science.** IAES Evaluation Function.
- Coccia, F., Armstrong, M., Asare, S. E., & Anand, S. (2024). **Evaluation of CGIAR Science Groups: RESULTS FROM ONLINE SURVEY**. IAES (CGIAR Independent Advisory and Evaluation Service).

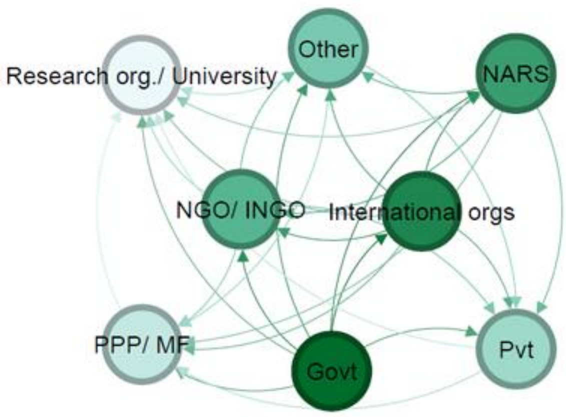
The **Independent Advisory and Evaluation Service (IAES)** conducted evaluations of CGIAR's three Science Groups (SG): Systems Transformation (ST), Resilient Agrifood Systems (RAFS), and Genetic Innovation (GI). All the CGIAR Research Initiatives have been organized around these three action Areas only. While each initiative is managed by a specific Science Group, scientists working on these Initiatives typically come from across the CGIAR System and partner organizations. The evaluations of these three Science Groups hence provided real-time feedback, ensuring accountability, and shaping the CGIAR portfolio, while informing the 2025-2027 Multi-Year Evaluation Plan. The design and conduct of SG evaluations aligned with CGIAR's Evaluation Framework and Policy, and guidelines on evaluating Quality of Science in CGIAR, key to achieving SDGs. The main goals of the SG-level evaluations were two-fold: firstly, to furnish real-time feedback and recommendations, towards institutional learning and adaptation of the CGIAR 25 Portfolio; and secondly, to facilitate accountability for, and learning from, the initial two years of 2030 portfolio implementation. In the context of these evaluations, the main survey instrument i.e. the Science Groups questionnaire was used to solicit information from a wide range of external and internal stakeholders, whose engagement is pivotal to ensure that diverse perspectives towards the collective insights to help guide CGIAR's evolution, was used to gather some data for conducting Social Network Analysis (SNA) as well. SNA was utilized in these entire SG evaluations primarily to:

- Understand collaboration of external partners like government, universities, NARS, etc. amongst themselves, and with the 14 CGIAR centres.
- Establish and understand the type of relationship among the partner organizations of CGIAR.
- Establish relationship among the participants in Science Group/Action Area based upon the CGIAR Center/organization they work with.
- Map primary and secondary initiatives from internal CGIAR staff.

The SNA conducted thus, aimed to identify and understand collaboration of external partners to CGIAR like government, universities, NARS, etc. amongst themselves, and with the 14 CGIAR centres. Furthermore, analysis aimed to establish the type of relationship among the partner organizations of CGIAR and also to establish relationship among the participants in Science Group/Action Area based upon the CGIAR Center/organization they work with. The focus was on comprehending the flows of information within different external partners and within the 14 CGIAR centres. Four sociographs were hence obtained – first showcasing relationship among the partner organizations of CGIAR based upon the CGIAR Centers they have collaborated with the most since 2022; second among the partner organizations of CGIAR based upon phase/type of partnership with CGIAR, third one establishing relationship among the participants in Science Group/Action Area based upon the CGIAR Center/organization they work with (as a staff or consultant) and lastly, a fourth one indicating relationship between external partners & CGIAR centres.

Social Network Analysis of the external partners and their relationship based upon the CGIAR Centres they have collaborated with the most since 2022 illustrates a moderate relationship. The survey questions provided insights about the type of external partners and how the external partner survey respondents engaged with CGIAR. The Sociograph (Fig 6) hence obtained revealed that the network of these external partners largely comprised eight different nodes/actors/organizations, namely, government (both national and subnational), international organizations which are multilateral in nature and have a regional or global reach like UN, AfDB, etc., National Agricultural Research and Extensions /Innovation System (NARS), National or international NGOs or Civil society organizations (NGO/CSO/INGO), private sector company, public-private partnerships or multi-stakeholder platforms (PPP/MF), universities/research organizations and some others, together boasting a network of 28 edges (linkages) and connections.

Figure 6. Network of external partners and their relationship



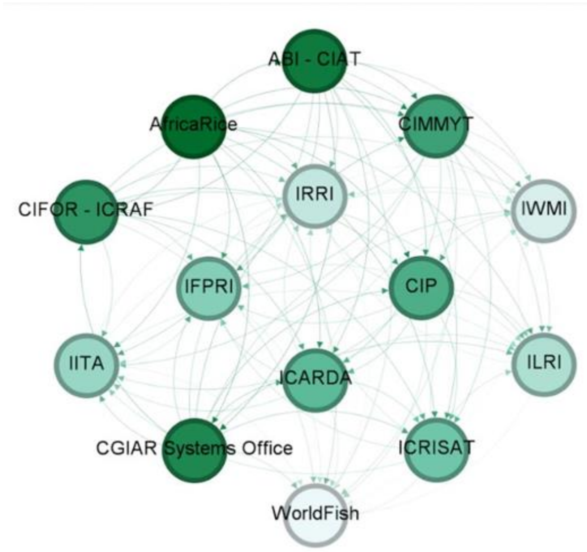
Nodes	8
Edges	28
Average Degree	3.5
Average Weighted Degree	3.5
Network Diameter	1
Graph Density	0.5
Connected Components	1
Modularity	0
Statistical Inference	49.23
Average Clustering Co-Efficient	0.5
Average Path Length	1

The graph density for this network of external partners represents a network density of 0.5 indicating that the network is only moderately cohesive in nature. Further the average degree of the network is 3.5 which implied that on an average, each node (i.e. external partner) is connected to at least three other nodes/external partners. A 0.5 average clustering coefficient of the present network of external partners indicate that these external partners may not be well known to each other. Not all the partners know each other well and hence, implying that there is moderate inter-connectivity among a given node/partner and hence efforts should be made to facilitate synergistic collaborations amongst them. Further, of the various nodes/external partners - research organizations/universities, private sector companies and public-private partnerships / multi-stakeholder platforms have high weighted in-degree (indicated by their light colour) indicating their immediate importance in the network as compared to the other nodes/external partners.

External partners reported their engagement with CGIAR in three different stages – design, implementation and diffusion. A plurality of the external partners (nearly 40%) reported to have engaged with CGIAR in the implementation stage of initiatives, co-development and/or piloting of any innovation. Further, the network of participants in the Science Group/Action Area based upon the CGIAR centre they work with indicates a moderately connected network (Fig 7). The average degree of the network is 6.5 indicated that each node is connected to at least 6 other nodes. Further, high weighted in-degree of WorldFish, IWMI & IRRI is indicative of its highly connected nature amongst all other CGIAR centres, followed by ILRI, IRRI, ICRISAT, IITA and IFPRI.

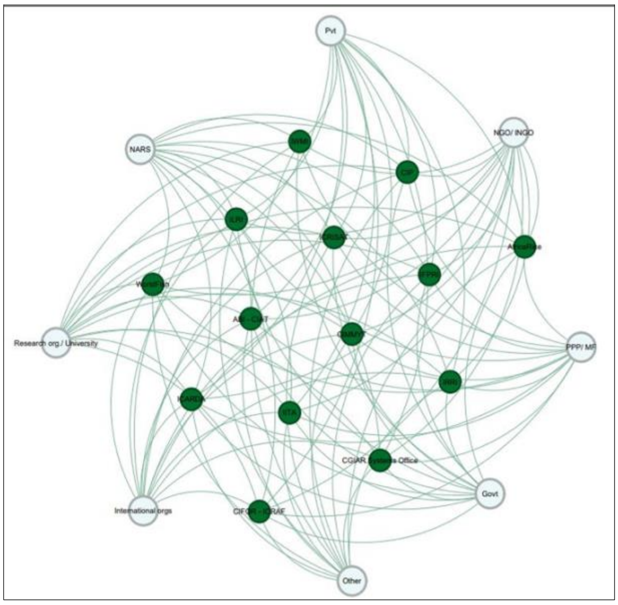
Nodes	14
Edges	91
Average Degree	6.5
Average Weighted Degree	6.5
Network Diameter	1
Graph Density	0.5
Connected Components	1
Modularity	0
Statistical Inference	138.132
Average Clustering Co-Efficient	0.5
Average Path Length	1

Figure 7. Network showing the relationship among participants in the various SGs



Additionally, a Bipartite SNA study to uncover the relationship between External Partners and CGIAR Internal partners revealed that the network of external partners with the CGIAR centres (/internal partners) comprised of 22 nodes/organisations having 112 connections and linkages (Fig 8). The average degree of the network was found to be 10 indicating that within the network the nodes/organizations (whether external partners or the CGIAR centres) are on an average connected to only 10 more nodes/organizations implying the need for building more cohesive network which could facilitate larger returns on investment by ensuring greater accountability and enhanced learning outcomes for CGIAR.

Figure 8. Network graph showcasing relationships between the external partners and internal partners of CGIAR



The network in figure 8 having a density of 0.48 indicated that 'every node' in graph had 48.5% of actual nodes actualized, and presented an opportunity for GGIAR centers to cross promote the external partners in order to maximize the collaboration between external partners and CGIAR centers. The study clearly brought out the need for collaboration and building of synergistic partnerships to enhance efficiency and ensure accountability. Both CGIAR internal respondents and external partners recognized financial challenges as the most significant challenge facing the evolving CGIAR portfolio: internal respondents highlighting procedural and managerial challenges, and external partners- thematic and strategic challenges more.

3.6 Social Network Analysis for Agrifood Systems Transformation

Read the full studies:

- Khan, N. A. M., Nag, A., Kamal, M., Nandi, R., Gathala, M. K., & Krupnik, T. J. (2024). TAFSSA stakeholder mapping: the agricultural production systems in Bangladesh. Research Note 26. TAFSSA. **https://hdl.handle.net/10883/35355**
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The TAFSSA (Transforming Agrifood Systems in South Asia)[11] initiative, led by CGIAR, spans South Asia to implement a coordinated research and engagement agenda that covers the entire food production-to-consumption continuum. The initiative aims to promote equitable access to sustainable, healthy diets, improve farmer livelihoods and resilience, and conserve critical resources such as land, air, and groundwater. Its success depends heavily on active participation from a diverse range of stakeholders, including public, private, and civil society actors, to ensure effective policy and technical coordination for transformative change across the food system.

As part of this effort, CIMMYT (International Maize and Wheat Improvement Center) conducted a mapping of agrifood stakeholder networks in Bangladesh, focusing on key system components: production, marketing, nutrition, and climate. This analysis identifies opportunities and barriers for change by viewing the agrifood system as an interconnected network of subsystems, driving integrated progress. The Net-Map[12] tool, a participatory approach, was employed to map the actors involved, their influence, and resource flows, such as funding and technical assistance. Four group interviews were conducted in Dhaka, producing one network map for each subsystem. The data from these interviews were digitized for quantitative analysis using the Datamuse[13] network analysis software, and the findings were validated through additional expert consultations.

The assessment of the significance of actors in the networks is based on key network indicators derived from the maps. Influence reflects an actor's potential for transformational change, considering factors such as formal authority, socio-economic status, expertise, and experience. Degree centralities represent the number of inbound and outbound ties, with a high number indicating a central position in the network. Boundary spanners act as bridges between otherwise disconnected actors, having high betweenness centrality, meaning they lie on the shortest path between other nodes. Finally, proactiveness measures the intensity of activities and initiatives an actor undertakes, regardless of their influence or connections. These indicators help identify the critical roles of actors in driving change within the system.

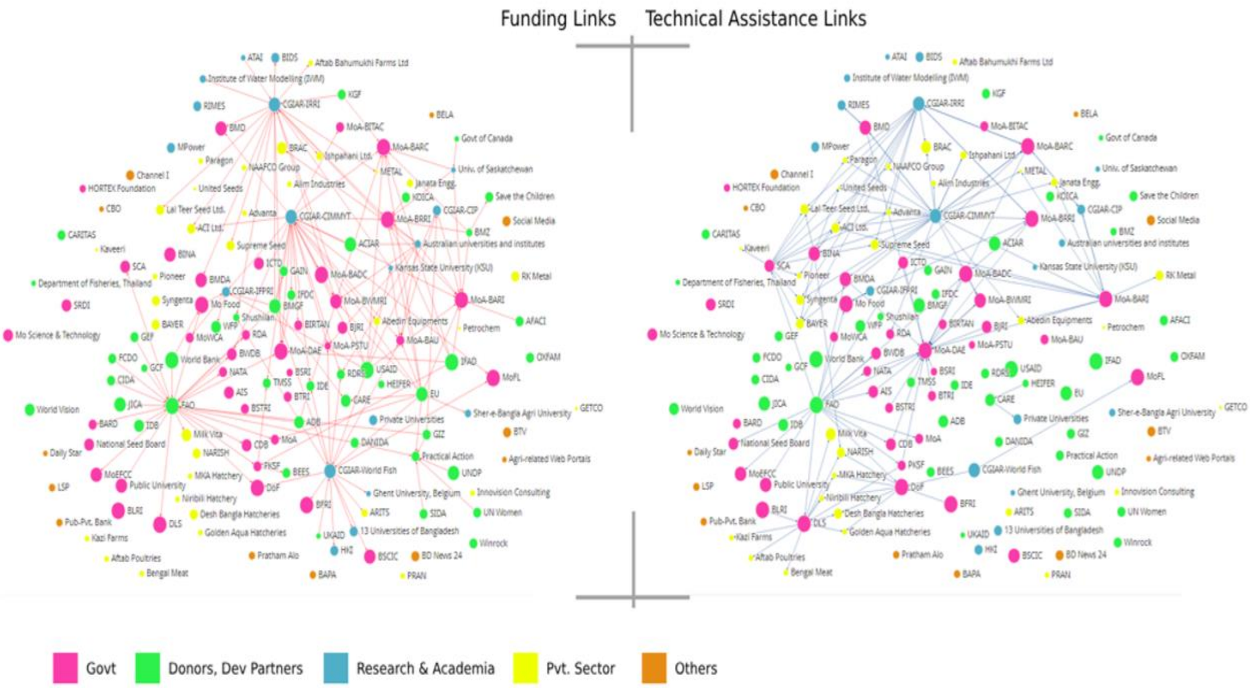
The resultant maps (example of production subsystem network map in figure 9) and analyses, including recommendations for structural changes towards a more integrated system, were shared with relevant

[11] https://www.cgiar.org/initiative/transforming-agrifood-systems-in-south-asia-tafssa/
[12] https://netmap.wordpress.com/
[13] https://datamuse.io/network/

stakeholders. Below are highlights from the Social Network Analysis exercise that informed recommendations for each subsystem.

The Ministry of Agriculture (MoA) leads the agricultural production network, supported by agencies like the Department of Agricultural Extension (DAE), Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Development Corporation (BADC), and institutes like BARI and BRRI. These agencies focus on technical assistance, seed production, research, and policy implementation. CGIAR centers (e.g., CIMMYT, IRRI, World Fish) and the FAO act as intermediaries, channeling funds and providing technical support to the government. Although the private sector plays a significant role in innovations related to hybrid seeds, mechanization, and crop protection, its involvement in policymaking remains limited, and it often relies on external technical support. Increased collaboration with the private sector and engagement in policymaking are essential to better harness its innovation capacity and address centralized knowledge flows.

Figure 9. Example of production subsystem network map



In the market systems and value chain network, the private sector operates largely as a self-sustaining ecosystem with minimal dependency on government or donor support. Key enablers include financial instruments like microfinance institutions (MFIs), private banks, and mobile financing, as well as distribution networks such as traders, retailers, and industry associations. Farmers' associations play a bridging role but have limited market influence. Multinational companies like Syngenta and Bayer, along with emerging social enterprises and e-commerce platforms, are reshaping the landscape. Government agencies, including Central Fresh Markets, LGED, DAM, and BSTI, provide regulatory, technical, and infrastructure support but face challenges in efficiency and integration. Strengthening collaboration among actors and improving storage infrastructure are critical to advancing the system.

The Ministry of Agriculture (MoA) leads nutrition policy, coordinating with the Ministry of Food, Ministry of Health and Family Welfare, and other ministries. The MoA drives initiatives to promote sustainable food production, while the Food Planning and Monitoring Unit (FPMU) monitor the National Food and Nutrition

Security Policy. The Bangladesh National Nutrition Council (BNNC) develops guidelines and coordinates efforts against malnutrition. However, policy implementation is weak due to limited capacity, insufficient follow-up, and a reliance on NGOs and project-based efforts. Donors such as FAO, GAIN, WFP, and UNICEF provide crucial support, with FAO and GAIN focusing on evidence-based policymaking and market-based nutrition programs, while WFP and UNICEF target capacity-building and assistance for vulnerable groups. Private sector engagement is hindered by unclear guidelines and a lack of government collaboration, compounded by bureaucratic barriers.

The government of Bangladesh plays a central role in climate change adaptation, with key ministries such as the Ministry of Agriculture (MoA), Ministry of Finance (MoF), and Ministry of Planning (MoP) coordinating efforts to promote climate-resilient agriculture. The MoA connects the government, donors, and the private sector, while the MoF manages funding for climate adaptation programs. MoP integrates climate adaptation into national development plans, and the Ministry of Fisheries and Livestock (MoFL) promotes resilience in livestock farming. Despite strong policies, implementation is weak, and alignment between the private sector and climate adaptation goals is lacking. Donors like UNDP and the World Bank provide essential support, but challenges such as low community participation and poor coordination among stakeholders undermine the success of climate action programs.

4 Ways Forward for Using SNA

Networks are complex systems and always ubiquitous. A quick look would help an individual appreciate the all-pervasive nature of networks. How people interact in formal and informal settings, how relationships are formed and why people get into formal and informal relationships, how organizations and communications within an organization are structured are only a few examples depicting the omnipresent nature of networks around us. Networks are crucial in various aspects for example, in public health, networks are important to understand disease transmission, social support mechanisms, dissemination of new ideas, and potential of existing and new policy/advocacy alliances. Network science is thus a promising field that addresses significant scientific inquiries using a network and complex systems approach and cuts across almost all the science and social science domains.

SNA has been used for a long period of time; however, the increasing popularity of SNA can be attributed to the advancements in Information and Communication Technologies (ICTs) that have made easier the task of capturing and graphically displaying large amounts of information. The growing number of development projects being conducted through partnerships and coalitions is another aspect leading to an increased emphasis on SNA. These partnerships range from simple to complex, involving multiple characters and diverse ties (Sette, 2013). Through SNA, partnerships can be better understood and improved to better serve the shared objectives. It can be utilized for diagnostic purposes during situational analysis or for project/program design.

SNA is applicable to networks of all sizes, from local to global. We can understand a plan, create another plan to support an existing network or create a new network and then monitor and assess a program/project using regular M&E approaches. Alternatively, we can also undertake a SNA exercise to assess changes over time. Such an analysis can help determine the causes and impact of these changes on network performance. Thus, SNA is a powerful approach for understanding relationships and dynamics within various social systems, including communities, organizations, and research networks. However, there are several challenges and limitations that researchers /development practitioners must consider when applying SNA, particularly when dealing with complex, real-world networks. The following is a list of some of these challenges:

1. **Accessibility of network data:** One of the most significant challenges of SNA is the accessibility and collection of network data. In many cases, obtaining detailed and reliable data on individuals' connections is a difficult task, especially when dealing with private or sensitive information. In social or organizational contexts, respondents may be unwilling or unable to provide accurate information about their relationships or interactions, owing to either privacy concerns, recall biasness, or due to the mere sensitive nature of certain networks for example, in conflict zones or with marginalized groups pf people. Additionally, there are inherent limitations in terms of the availability of historical data, particularly when dealing with longitudinal network analysis.
2. **Quality of network data:** Network data often comes with inherent issues such as incomplete or inconsistent reporting of relationships. For instance, individuals may over-report or under-report the strength or nature of their connections, leading to biased network maps. Furthermore, self-reported data can introduce subjective interpretations that may not reflect the true nature of the interactions or the structure of the network. Thus, the quality of data is another big challenge. Poor-quality data can often skew results, leading to misinterpretations of network dynamics.
3. **Possible misinterpretation of the network data**: SNA requires a detailed understanding of the relationships between network members, but gathering this level of granularity can be resource intensive. Thus, development practitioners must define the boundaries of the network (e.g., what is the unit of analysis and who to include in the analysis) and determine which types of relationships are relevant for a given study/intervention. The level of detail needed for a meaningful analysis may not always be feasible, particularly when data is sparse. This limitation can lead to incomplete representations of network dynamics, where important connections or influential nodes may be overlooked.
4. **Dynamic nature of networks**: Social networks are not static; they are dynamic and constantly changing over time. One of the challenges of SNA is capturing and analyzing these changing dynamics. Relationships may evolve, new connections may form, and old ones may fade. Tracking these shifts requires continuous data collection and sophisticated modeling techniques. Failing to account for temporal changes in a network can result in an incomplete or outdated understanding of how the network functions, potentially leading to misinterpretations of its stability, resilience, or effectiveness.
5. **Oversimplification and misinterpreting network dynamics:** SNA can sometimes lead to over-simplified interpretations of complex social phenomena. For example, the presence of a strong tie between two individuals in a network does not necessarily imply collaboration or mutual benefit. Social network data often fails to capture the context or depth of relationships, and thus, researchers may erroneously attribute significance to certain network patterns (e.g., strong ties or central positions) without understanding the qualitative aspects of those connections. Moreover, network analysis often focuses on structural aspects of a network (such as connectivity or centrality) while neglecting the subjective, cultural, and emotional components of social relationships, which can be equally important for understanding social behavior.
6. **Ethical considerations:** Like other research methods, applying SNA too is poised with genuine ethical considerations. Issues such as ensuring privacy of the respondent and confidentiality of the data shared are key ethical considerations to keep in mind.
7. **High reliance on quantitative measures:** While SNA provides valuable quantitative metrics, such as centrality, density, and betweenness, it can sometimes overshadow the qualitative aspects of network functioning. Relying too heavily on these metrics can lead to a reductionist view of social relationships, neglecting factors such as trust, reciprocity, and social capital that are not always easily quantified. Moreover, a purely quantitative approach may miss important nuances, such as informal or unspoken connections that influence the network's dynamics. Despite the complexity of

network analysis and its inherent challenges as mentioned above, various development organizations (NGOs, CSOs, bilateral organizations) can still employ SNA for influencing policy and for mobilization purposes. SNA is already widely used in the development sector to map and analyze knowledge networks and communities of practice. Since it is evident and widely accepted that attaining significant and long-lasting improvements at different levels requires an intersectoral approach that recognizes and takes use of the many factors, players, and sectors at play, SNA can be used to describe the intersectoral collaboration between the organizations that focus, for instance, on WASH, MCH, environment and education. SNA can be used to monitor stakeholder relationships, intervene, improve, and facilitate the implementation of projects requiring intersectoral partnerships. However, the application and utilization of SNA in the development sector comes with a word of caution.

Thus, key points to help ensure apt use of SNA in various stages of a development project cycle are:

1. SNA must be applied under the supervision of a trained SNA expert only. In case this is not feasible, a capacity training of the staff is required to decipher the context of a given evaluation and to design/draft the data collection tools in accordance with the needs of the project.
2. Care should be taken in defining the scope of SNA. For the same, a feasibility assessment can be done in the beginning phase of a project/program.
3. SNA can be done online as well as offline. The tools for data collection for doing an SNA involve regular surveys, interviews and focus group discussions. The tool used to collect the data for SNA must however be pilot tested to remove any ambiguity and unforeseen biases.
4. Due care is needed to avoid any oversimplification of the process of carrying out SNA to evaluate an intervention.
5. SNA can be used at the planning stage as well as towards the end to identify the key players/stakeholders, recognize the pathways of communication, assess the strength of bonds between different players and stakeholders. The case studies detailing the use of SNA in the developmental evaluation are still limited in number. There is a need to expand the scope of SNA and utilize the potential of SNA as a planning and evaluation tool. However, the development practitioners need to acknowledge the existing gap between literature and the practical know-how, inherent challenges of using SNA and must be cautious of over-using the tool.
6. Deliberate and sincere efforts are needed both on part of the evaluators as well as commissioners of evaluation to ensure more participatory use of SNA. This is especially important to avoid its utilization as a mere quantitative tool for visualization and refrain from making the whole process of evaluation heavily top-down.

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