

COMPARATIVE ANALYSIS OF REGIONAL NATIONAL RESEARCH AND EDUCATION NETWORK (NREN) CONSORTIUMS: COMPARING MEMBERSHIP, GOVERNANCE, FINANCING, AND REGIONAL CONTEXTS IN THE GLOBAL SCENARIOSD Withanage¹, RG Ragel² and K Gunasekera³**Abstract**

This research undertakes a comprehensive comparative analysis of regional National Research and Education Network (NREN) consortiums, examining critical elements such as membership criteria, governance models, financing mechanisms, and the influence of regional contexts. The objective is to delineate best practices and provide recommendations to enhance the effectiveness, inclusivity, and sustainability of NREN consortiums globally. The analysis reveals that NREN consortiums vary significantly in their membership criteria, with some offering multiple membership categories beyond the core NREN members. Governance models predominantly feature a Board of Directors, although community governance models are also practiced. Financing mechanisms primarily rely on membership and service fees, with some consortiums in lower-income regions benefiting from grant funding. Regional contexts play a crucial role in the formation and operation of NREN consortiums. Political stability and economic strength are notably higher in American and European regions compared to African and Asian regions, where conditions vary widely. Technological advancement and digital connectivity are also more developed in American and European regions, while cultural and social factors exhibit significant diversity across all regions. Based on these findings, the study recommends enhancing membership criteria to be more inclusive, adopting effective governance models, diversifying financing mechanisms, and tailoring strategies to regional contexts.

Keywords: Consortium, Finance mechanism, Governance, Membership, NRENS

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Introduction

Background

National Research and Education Networks (NRENs) cater to the unique needs of research and education communities in countries. While invaluable nationally, these networks often recognize the potential for transformative impact through collaborative efforts. Consequently, NRENs usually join forces in proximity, forming consortiums strategically designed to pool resources, augment capabilities, and collectively address the multifaceted challenges encountered in research and education. Globally, NREN consortiums are vital for advancing research, promoting innovation, and closing the digital divide by sharing resources and providing fast internet to academic institutions. By working together, NRENs can better tackle the challenges in research and education, especially as the world moves towards knowledge-based economies.

In the global context, several NREN consortiums are available in different regions where the regional NRENs get together and form regional NREN consortiums to achieve common goals or objectives. Since the NRENs are working towards serving the requirements of the research and education sector and enhancing its capabilities, the objectives of these regional consortiums remain almost similar. Yet, there are significant differences in their organizational frameworks.

This research focuses on understanding the differences in organizational frameworks of NREN consortiums, specifically in membership criteria, governance structure, and financing mechanism. It also includes a comprehensive analysis of regions with different criteria, including political stability, governance, economic strength, market size and openness, cultural diversity, social acceptance, technological advancements, digital connectivity, educational institutions, and research output.

Problem Statement

Regional NREN consortiums play a critical role in enhancing the capabilities of research and education institutions by fostering collaboration, sharing resources, and advancing technological infrastructure. However, there is significant variation in how these consortiums are structured and operate across different regions of the world. Factors such as membership criteria, governance models, financing mechanisms, and regional contexts—including political, economic, and technological conditions—greatly influence the effectiveness and sustainability of these consortiums. Despite the global presence of NREN consortiums, there is a lack of comprehensive comparative research examining these differences and their impact. Understanding these variations is crucial for identifying best practices and developing strategies to strengthen NREN consortiums globally. This research aims to address this gap by analyzing and comparing NREN consortiums worldwide, focusing on their membership structures, governance, financing, and the influence of regional contexts.

Objectives of the Research

Two (02) significant objectives of this research.

- To examine existing collaborations among NRENs in different regions of the world
- To identify and compare different aspects of NREN collaborations focused on
 - Membership criteria
 - Governance structure
 - Financing mechanism
 - Regional context

Literature review

Introduction to NRENs

NRENs provide a dedicated infrastructure for the research and education community, facilitating the sharing of resources and expertise (McClure et al., 1991). They are also instrumental in providing affordable high-speed bandwidth and other advanced services to the academic community, such as electronic repositories, educational environments, and supercomputing facilities, contributing to the transformation to a "Knowledge Society" (Janz & Kutanov, 2012). NRENs play an essential role in the development of communication network infrastructure and networked services by providing high-speed, low-latency connectivity and advanced network services to virtual communities in collaborative research and education projects (Villalón & Hermosa, 2016; Kashefi et al., 2019). As per Janz & Kutanov (2012), an NREN exhibits the following characteristics,

1. Provide services for a closed user group
2. Not-for-profit organizations
3. Provide at least national and international connectivity
4. Besides connectivity, NRENs provide other services for their users

Not limited to a national level, the NRENs play a critical role in advancing scientific collaboration, innovation, and knowledge exchange on a global scale. The development of NRENs has been a global phenomenon, with significant progress made in the early 1990s (McClure et al., 1991). They have also been crucial in advancing technologies and promoting international research collaboration (Schleyer et al., 2012).

The importance of NRENs in bridging digital divides and supporting national and international development has been emphasized, particularly in regions such as West and Central Africa (Kashefi et al., 2019). The role of NRENs in developing communication network infrastructure and networked services for researchers and educators has been highlighted in this study. Establishing research networks and collaborations provides the necessary flexibility to adapt to a broad spectrum of arising challenges (Puljak & Vari, 2014).

Global NREN Collaborations

A "consortium" is a collaborative framework allowing flexible transactions and interaction modes (Kouramajian et al. 1995). As voluntary partnerships, consortia are key players in collaborative efforts, particularly in the library and academic sectors (Hooper-Bùi et al., 2018; Armstrong & Teper, 2017; Cherubini & Kraus, 2011; Gunjal, 2020; Johnson, 2006). Phillips et al. (2000) have defined collaboration as a cooperative relationship among organizations that relies on neither market nor hierarchical mechanisms of control. They explain that collaborations are crucial for the structuration of institutional fields.

Shared goals play a crucial role in the collaboration of organizations, driving motivation and direction (Adler & Heckscher, 2018). They can be particularly effective in addressing common concerns and engaging diverse worldviews (Chapin, 2020). These provide shreds of evidence that common goals are crucial to forming partnerships. Collaborations have been formed in different domains and industries aiming for different goals. Collaborations are significant in higher education, where they can enhance academic performance, achieve economic efficiencies, and align institutions with public needs (Williams, 2017).

A regional research and education network collaboration can bring many benefits. These networks often involve universities, research institutions, and other stakeholders and can be regionally or thematically

focused. They play a crucial role in facilitating the exchange of information and best practices and promoting innovation and regional development (Ata, 2007; Hansen et al., 2002).

Jensen & Bergqvist (2012) have highlighted the potential for resource pooling and coordination within NREN collaborations. This is particularly beneficial in the context of specialized education and distance learning, where resources may be scarce or unevenly distributed. Boronenko et al. (2018) also underscore the importance of resource pooling and coordination in collaborations. Hammond (2019) and Woolcott et al. (2019) have further highlighted the role of these collaborations in knowledge production. They suggest that these networks can contribute to societal integration and develop tailored educational solutions by working together. Khaparde & Srivastava (2003) underscore the importance of regional cooperation in academic research. He argues that such cooperation is crucial for addressing local and regional challenges unique to a particular area or population.

Key Factors in NREN Consortium Formation

A range of factors influence the formation and success of consortia across industries. In the research and development industry, industry competition and appropriability conditions, a firm's R&D capabilities, and past participation in large-scale consortia are key factors (Sakakibara, 2002). Choosing partners is also critical, as the right partners increase opportunities and decrease risks (Walther, 2015). In the export consortiums, joint learning actions, cooperation, and innovation determine efficiency (Amorim J. E. O. ; Forte, Sérgio Henrique Arruda Cavalcante, 2007). In e-business standardization, firms' interests, resource availability, and consortium management effectiveness drive resource investments (Kexin Zhao & Shaw, 2011).

Successful collaboration and consortium management require a clear understanding of the benefits of working together and a commitment to achieving common goals (Khaparde & Srivastava, 2003). Pangarkar & Klein (2001) and Ongsakul et al. (2019) highlight the importance of the purpose and partner similarity in determining the governance structure of a consortium. Nielsen (2003) and Teng & Das (2008) further underscore the significance of strategic motivation, governance mode, and partner nationality in driving alliance formation and influencing governance structure choice. These studies collectively suggest that the feasibility factors of *membership criteria*, *governance structure*, and *financing model* are crucial in shaping the formation and success of a consortium or alliance.

NRENs are a special entity that focuses on serving the research and education communities; almost all are not-for-profit organizations. The following papers provide a range of factors that influence the success of the Not for Profit (NFP) consortium formation. These include the choice of partners (Walther, 2015), the social or institutional composition of the consortium (Wanzenböck et al., 2020), and the need to utilize the full value-creation potential of the firm's resources. Commitment, coordination, and communication are also crucial (Dodourova, 2009). The role of corporate governance in NFP organizations is significant, with cooperation being a key driver of wealth maximization (Romano, 2013).

With a foundational understanding of key factors influencing consortium formation across various industries and specifically the unique nature of the NREN consortium, this study will thus concentrate on only four critical areas: membership criteria, governance structure, financing mechanisms, and geopolitical dynamics.

Membership Criteria

Clear membership criteria are essential for maintaining the integrity and consistency of any organization. At the level of professional, totalitarian and bureaucratic organizations as social segments, membership is modified as “belonging status”, organizational identity, subordination and involvement (Surovtseva, 2020). It can provide access to services, participation in a community, support for a cause, like-minded connections, prestige, special privileges, and networking opportunities (Weissman, 2014). "Setting Clear Membership Criteria for Nonprofit Organizations" emphasizes the importance of defined criteria for ensuring qualified membership and organizational mission alignment (*National Council of Nonprofits*, n.d.)._American Society of Association Executives (ASAE) discusses the need for clear membership criteria to maintain integrity and reputation within corporate and professional organizations (*Welcome to ASAE — American Society of Association Executives*, n.d.).

Governance Structure

Inclusive governance structures are important for promoting diversity, equality, and inclusivity in various contexts, including higher education (Graham Wise Connie Dickinson & Gallegos, 2020), public administration (Emerson et al., 2011), and nonprofit organizations (Brown, 2002). Brown (2002) explains that nonprofit organizations need a better understanding of what inclusive governance looks like in practice. An inclusive board demonstrates awareness of the community and constituents who benefit from and contribute to the services of the organization (Barbero et al., 2019), seeks information from multiple sources (Daley & Angulo, 1994), and establishes policies and structures (such as committees) to foster stakeholder involvement (Duca, 1996).

Financing Mechanism

Financing mechanisms are essential for securing the necessary funds for any organization’s operations. They can take multiple forms, such as loans, grants, equity investments, bonds, and public-private partnerships (Podyk, 2023). Various financial mechanisms are crucial for the sustainable development of not-for-profit organizations (NPOs) and non-governmental organizations (NGOs) (Pyanov et al., 2021). The economic and credit mechanism of an enterprise, a subset of the finance mechanism, is a set of interrelated financial processes, instruments, methods, and resources used to ensure the enterprise’s activities, implement strategic goals, and achieve economic stability (Podyk, 2023).

Geopolitical Dynamics

When geopolitical relationships are stable, countries can engage in consistent and cooperative international policies, trade, and diplomatic relations. This stability reduces the risk of conflicts, encourages foreign investments, and enables long-term planning for development and security (Friedman, 2009). According to the World Bank Report, 2011, the relationships and interactions between countries and regions are relatively predictable and peaceful in the presence of stable geopolitical conditions. Geopolitical and geo-economic shifts in the region are ongoing, so, naturally, there is a process of adaptation that creates a bit of friction with domestic politics (Erlangga, 2018).

In summary, this literature review has identified and elaborated on four critical factors that influence the formation and success of NREN consortia: membership criteria, governance structures, financing mechanisms, and the impact of geopolitical dynamics.

Comparative analysis

Comparative analysis of organizations can reveal unexpected similarities and differences by examining cross-level, contextual factors (Whetten 2009). According to King et al. (2009), comparative analysis can be used to explain and describe organizational heterogeneity at varying levels and contexts. He

further explains that one advantage of comparative analysis is the ability to assess the observed differences between organizations and by examining differences between organizations, researchers can assess the sources of heterogeneity within fields and industries, offering a more comprehensive understanding of organizational phenomena.

Research methodology

Data Collection and Analysis

The research proceeded with a detailed literature review and secondary data collection to identify the existing global NREN consortiums. Through the secondary data collection, different NREN consortiums in different regions of the world were identified, and their form of establishment was based on membership criteria and participation guidelines, a financing mechanism, a governance structure, and a regional context.

When collecting details on regional NREN collaborations, it was identified that the details and publications available on the GÉANT website (<https://geant.org>) provide appreciable information on GÉANT itself and other regional collaborations worldwide. *Figure 3.1* visually represents regional NREN consortiums available worldwide and GÉANT’s connection with them.

GÉANT is the pan-European data network for the research and education community. It interconnects national research and education networks across Europe and exerts appreciable effort in connecting with other regional collaborations.

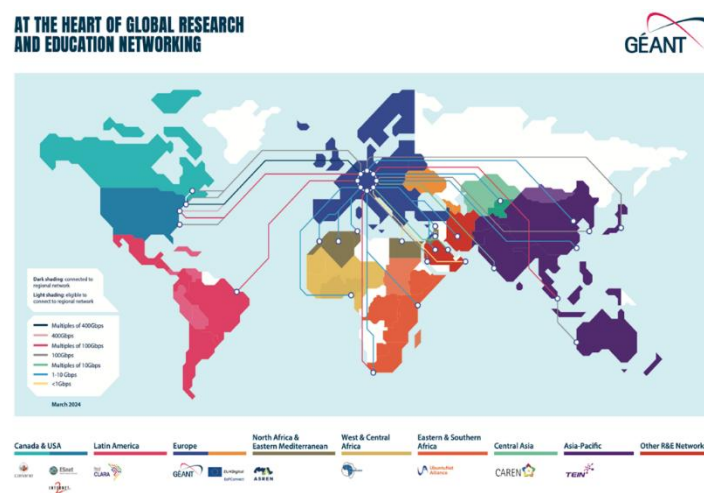
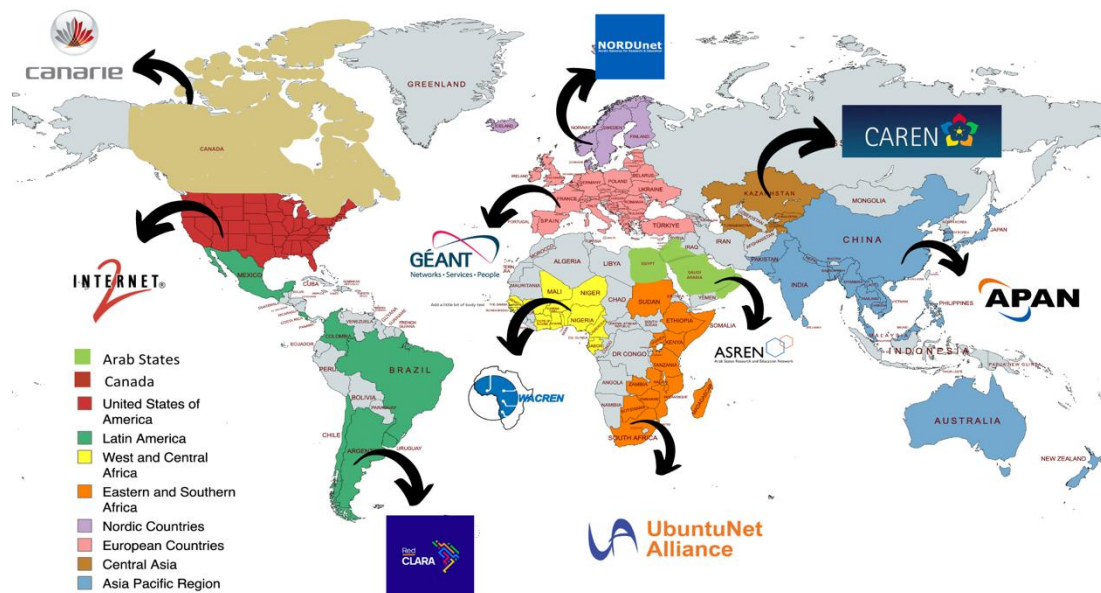


Fig 3.1: Global Connectivity Map of GÉANT

(Source: <https://resources.geant.org/maps/>)

Referring to the details in *Figure 3.1* and other online sources, worldwide regional NREN consortiums were identified, as shown in *Figure 3.2*. Table 3.1 shows a summary of those consortiums.

Figure 3.2: Regional NREN Consortiums



(Source: Developed by Author)

Table 3.1: Summary of regional NREN consortiums available worldwide

Region	NREN Consortium	Description	Source
America	CANARIE	“The Canadian NREN that supports advanced networks and technology to facilitate research and education. It connects 13 provincial and territorial R&E networks in Canada.”	(Canada’s National Research and Education Network - CANARIE, n.d.)
	Internet2	“A collaborative effort among regional and state education networks, universities, government agencies, and community anchor institutions in the United States of America working on advanced networking and technology initiatives.”	(Home - Internet2, n.d.)
	RedCLARA	“A collaboration of Latin American NRENs in 13 Latin American countries connecting research and education	(Home RedCLARA, n.d.)

		networks across countries in the region.”	
Africa	UbuntuNet Alliance	“An association of National Research and Education Networks in 13 countries in Eastern and Southern Africa. It works towards the establishment and management of a regional high-speed internet network dedicated to the research and education community.”	<i>(Ubuntunet Alliance – For Research & Education Networking, n.d.)</i>
	WACREN	“A regional NREN consortium that aims to promote the deployment of advanced networks and technologies in 11 countries in West and Central Africa to support research and education.”	<i>(Home - WACREN, n.d.)</i>
	ASREN	“It is an association of NRENs from the Arab region, along with strategic partners. ASREN’s mission is to implement, manage, and expand sustainable Pan-Arab e-infrastructures dedicated to the research and education communities.”	<i>(Arab States Research and Education Network, n.d.)</i>
Europe	GÉANT	“A pan-European data network dedicated to the research and education community. It interconnects national research and education networks, creating a high-performance, secure, and reliable communications infrastructure in the European region.”	<i>(GÉANT, n.d.)</i>
	NORDUnet	“Supplies connectivity between the NRENs of the five Nordic countries and supports over 400 institutions.”	<i>(Home - NORDUnet, n.d.)</i>
Asia and Asia Pacific	CAREN	“A project that was launched in 2009 with the goal of providing a high-capacity internet network for the research and education communities in Central Asia1. The network facilitates communication, information exchange, and collaboration between universities and research centers across the region.”	<i>(CAREN Project – ICAREN, n.d.)</i>
	APAN	“Not-for-profit Association of Asia-Pacific NRENs incorporated in Hong	<i>(Asia Pacific Advanced Network, n.d.)</i>

		Kong as a company limited by guarantee.”	
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Comparative analysis is a valuable method in research that involves comparing two or more entities to identify similarities, differences, and patterns. The Qualitative Comparative Analysis (QCA) method introduced by Charles Ragin in 1980 was utilized in this research. Each criterion-membership, governance, financing, and regional context is analyzed across various NREN consortiums one by one. The comparison is structured around key variables: membership criteria, governance models, and financing mechanisms. A comparison of regional contexts (including political stability, economic strength, and technological infrastructure) was included to get a better understanding of regional behaviour.

Membership Criteria Analysis

After identifying the different NREN consortiums operating globally, the membership criteria of each were observed, and different membership categories were identified. The collected data on membership categories were summarized and presented in Table 3.2. The multi-value data coding method was used to code the data. Hence, only “Research and Education Network (REN) Members” were denoted by “0”. Entities offering membership criteria for REN members and other associate/affiliate members excluding Industry partners were denoted by “1”. Entities offering membership criteria for all REN members, associate/affiliate members and Industry partners were denoted by “2”.

Table 3.2: Summary of membership categories

Network	Membership Criteria	Membership Category	Code
CANARIE	Offer membership to the leading research, education, and innovation organizations and contribute to evolving Canada’s digital research infrastructure. Applications are subject to the approval of the CANARIE Board of Directors. Source: CANARIE website (www.canarie.ca/nren/)	1. Research and Education Network Members 2. Higher education institutes (colleges, universities, research institutes) 3. Other innovative organizations	1
Internet2	Membership is divided into four levels based on annual operating budgets for Affiliate members, and annual revenues for Industry members. The member’s level determines its annual membership dues and network participation fees. Source: Internet2 website (https://internet2.edu/)	1. Higher Education Members 2. Affiliate Members 3. Industry Members 4. Research and Education Network Members	2

RedCLARA	To become a full associate, an entity must manage an academic, scientific and/or research network at a national level in a country, have support from the Government of the country represented, and request its incorporation into the Association through a formal letter addressed to the Directing Council. Only one NREN per country can be a RedCLARA member. Source: RedCLARA website (https://www.redclara.net/en/)	Research and Education Network Members	0
UbuntuNet Aliance	The UbuntuNet Alliance is a membership organization of National Research and Education Networks (NRENs) in Eastern and Southern Africa. They collectively seek to facilitate access by the region’s knowledge communities to their global research and educational resources. Source: UbuntuNet Alliance website (https://ubuntunet.net/)	Research and Education Network Members	0
WACREN	WACREN offers membership to organizations in education and research. Members of WACREN play a critical role in the governance and evolution of the organization, helping ensure West and Central Africa remains at the forefront of research and innovation. Source: WACREN website (https://wacren.net/en/)	<ol style="list-style-type: none"> 1. NREN Member 2. Associate Member 3. Premium Associate Member 4. Corporate Member 5. Premium Corporate Member 6. Partner Member 	2
ASREN	Coordinates Arab region National Research and Education Networks (NRENs) and strategic partners, aiming to build, manage, and expand sustainable Pan-Arab e-Infrastructures. Source: ASREN website (https://www.asren.net/)	Research and Education Network Members	0
GÉANT	Owned by its core membership, including 36 National Members which are European NRENs, and one Representative Member – NorduNET. Associates include commercial organizations and multi-national research infrastructures and projects	<ol style="list-style-type: none"> 1. Research and Education Network members 2. Associates 	1

	Source: GÉANT website (https://geant.org/)		
NorduNET	Primarily serves the Nordic countries, connecting research and education networks to the rest of the world. Membership is based on being part of the Nordic research and education networks. Source: NorduNET Website (https://nordu.net/)	Research and Education Network Members	0
CAREN	Membership details are not explicitly stated, but it appears to be focused on NRENs in Central Asia, aiming to be part of a large user group representing academic institutions in the region Source: CAREN website (https://icaren.org/)	Research and Education Network Members	0
APAN	APAN has one category of Voting Member, also known as Primary Member, which is typically an entity that coordinates advanced research and education network provisioning within a country/economy. There are also four categories of Non-voting Members: Associate, Affiliate, Liaison, and Industry Members, with each having different roles and interests aligned with APAN’s objectives. Source: APAN website (https://apan.net)	<ol style="list-style-type: none"> 1. Primary Members 2. Associate Members 3. Affiliate Members 4. Liaison Members 5. Industry Members 	2

Governance Structure Analysis

The governance structures of NREN consortia vary, with some similarities and distinct models across entities. The gathered data on each consortium's governance model are summarized and presented in Table 3.3. The multi-value data coding method was used to code the data. Hence, "Board of Directors" was denoted by "0." Entities having a "Board of Trustees" were denoted by "1." "Community Governance" was denoted by "2," and if data was unavailable, it was denoted by "3."

Table 3.3: Summary of Government Structures

Consortium	Governance Structure	Governance Model	Code
CANARIE	Governed and managed by the NREN Governance Committee, including the president of CANARIE and leaders of provincial and territorial networks. Source: CANARIE website (www.canarie.ca/nren/)	Board of Directors	0
Internet2	Internet2 is governed by members of the Internet2 community, including university presidents, chancellors, CIOs, industry and regional representatives. The Board of Trustees provides strategic direction, leadership, and oversight for Internet2. Source: Internet2 website (https://internet2.edu/)	Community Governance	2
RedCLARA	Governed by an Assembly, Board of Directors, and Technical Commission. Members include various Latin American countries' national research and education networks. Source: RedCLARA website (https://www.redclara.net/en/)	Board of Directors	0
WACREN	The Board of Directors comprises six members including the Chair and CEO. Directors are nominated for three-year renewable terms. Source: WACREN website (https://wacren.net/en/)	Board of Directors	0
Ubuntunet Alliance	Governed by a Council of Members, a Management Board, and a Secretariat. It operates with a three-tier structure. Source: UbuntuNet Alliance website (https://ubuntunet.net/)	Board of Trustees	1
ASREN	No specific governance structure details were found.	Not Available	3
NorduNET	Managed by a Board consisting of members from five partnering countries. The Board resolves overall political and strategic issues. Source: NorduNET Website (https://nordu.net/)	Board of Directors	0
GEANT	The highest governing body is the General Assembly, which elects members to the Board of	Board of Directors	0

	Directors. The Board manages and administers the organization. Source: GÉANT website (https://geant.org/)		
CAREN	No specific information found on the governance structure.	Not Available	3
APAN	Comprises a Board of Directors, General Meeting of Members/Council of Primary Members, and various committees and working groups. Source: APAN website (https://apan.net)	Board of Directors	0

Financing Mechanism Analysis

The study observed the financing mechanisms of each NREN consortium selected. This included the financing received for the consortium's initial establishment and the methods of revenue generation for operational activities and long-term sustainability. The summarized data are presented in Table 3.4. The multi-value data coding method was used to code the data, and coding was done as follows,

- Membership fees and service fees only – “0”
- Membership fees and project grants – “1”
- Membership fees, Service fees and corporate partners – “2”
- Membership fees, service fees and grants – “3”
- Membership fees, service fees and corporate partners – “4”
- Membership fees, service fees and funds and corporate partners – “5”

Table 3.4: Summary of Financing Mechanisms

Consortium	Initial Establishment Funding	Revenue generation	Code
CANARIE	Initially funded by the Government of Canada. Source: CANARIE website (www.canarie.ca/nren/)	From membership fees, government grants, partnerships and service fees	5
Internet2	Started with various sources including government grants. Source: Internet2 website (https://internet2.edu/)	From member fees, corporate partners, and service fees.	4
RedCLARA	Received initial funding from the European Union and Latin American NREN community. Source: RedCLARA website (https://www.redclara.net/en/)	From membership fees, project funds, Partnerships and service fees	5

UbuntuNet Alliance	Substantial initial funding from the European Union under the Africa Connect Programme. Source: UbuntuNet Alliance website (https://ubuntunet.net/)	From membership fees and service provision to members.	0
WACREN	Incubation started with support from the Africa Network Operation Group (AfNOG) and the Association of African Universities (AAU). Source: WACREN website (https://wacren.net/en/)	From membership fees and possibly project grants.	1
ASREN	Established with the support of member NRENs and strategic partners. Source: ASREN website (https://www.asren.net/)	From membership fees and project funding.	1
GEANT	Funded under the Horizon Europe framework by the European Commission. Source: GÉANT website (https://geant.org/)	From membership fees and project funds.	1
NorduNET	Receives public financing for specific projects like the Arctic gateway to Asia. Source: NorduNET Website (https://nordu.net/)	Membership fees from Nordic NRENs and service fees.	0
CAREN	Jointly funded by the EU and Central Asian NREN partners for initial establishment. Source: CAREN website (https://icaren.org/)	Membership fees and service fees from participating countries.	0
APAN	The total budget for regional operations is USD 2.5 million per annum, not exclusive to loss and damage but covering all activities. Source: APAN website (https://apan.net)	From membership fees and possible project grants.	1

Regional Context Analysis

This study conducted a comprehensive analysis of regions worldwide based on predefined criteria, as shown in Table 3.5.

Table 3.5: Summary of Regional Context

Factors		America	Africa	Europe	Asia
Political Stability and Governance	Political Stability	Usually high, with vigorous democratic institutions and steady governance	Varies widely; some countries experience substantial instability (e.g., conflicts, coups), while others (e.g., Botswana, Ghana) are comparatively stable	Normally, very high, with robust democratic institutions and a history of steady governance	Varied; East Asia (e.g., Japan, South Korea) is very stable, while South Asia (e.g., India, Pakistan) and parts of Southeast Asia (e.g., Myanmar) face more challenges
	Governance	Robust legal frameworks and regulatory systems facilitate business operations and consortium formations	The quality of governance varies, with factors like corruption and weak institutions affecting the formation of consortiums	Inclusive legal and regulatory frameworks support consortium operations. The European Union offers an additional layer of governance and care for cross-border collaborations	Differs significantly; countries like Japan and South Korea have strong governance, while others brawl with fraud and regulatory inadequacies
Economic Factors	Economic Strength	Robust economies, mainly in the US and Canada, with high GDP and substantial investment potential	Usually lower GDP, but with some fast-growing economies (e.g., Nigeria, South Africa)	Robust and varied economies, with high GDP and well-known markets	Mixed, with highly advanced economies (e.g., Japan, South Korea) and developing ones (e.g.,

					India, Bangladesh)
	Market Size and Openness	Large and open markets, enabling large-scale consortiums	Emerging markets with important growth potential but also high risks	Extremely combined markets, especially within the EU, offering a huge and reachable market for consortiums	Large markets with important growth potential, but also fluctuating degrees of market openness
Cultural and Social Factors	Cultural Diversity	Massive cultural diversity, nurturing innovation and collaboration	Enormously varied cultures and languages	Varied but with a robust prominence on collaboration and integration, especially within the EU	Extremely diverse, with substantial cultural differences between countries
	Social Acceptance	Usually, high acceptance of consortiums and collaborative business models	Differs, with some societies being more public and others more individualistic, impacting consortium dynamics	High acceptance of collaborative projects and consortiums	Differs; some cultures highlight hierarchical structures which can impact collaborative efforts
Technological Infrastructure	Technological Advancements	Very advanced, with important investments in R&D and technology infrastructure	Differs extensively; some countries are progressing rapidly, while others lag significantly	Vastly advanced, especially in Western and Northern Europe	Diverse; countries like Japan, South Korea, and China are leaders in technology, while others are developing
	Digital Connectivity	High internet penetration and advanced digital	Usually lower internet penetration, though mobile connectivity is growing fast	High levels of internet penetration and advanced digital	High in East Asia, but lower in parts of South and Southeast Asia

		infrastructure		infrastructure	
Educational and Research Capabilities	Educational Institutions	Housing numerous world-leading universities and research institutions	Differs, with a few robust universities but usually lower global rankings	Several top-ranking universities, especially in Western Europe	Diverse; world-class universities in Japan, China, and South Korea, with others developing
	Research Output	High levels of research and innovation, maintained by considerable funding	Limited by funding and infrastructure, though improving in some regions	High research output, maintained by EU funding and collaborative frameworks	Increasing quickly, particularly in East Asia, with substantial investments in R&D

Sources:

World Bank. (2023). Governance Indicators; <https://www.worldbank.org/en/publication/worldwide-governance-indicators/interactive-data-access>

International Monetary Fund. (2023). World Economic Outlook Database; <https://www.imf.org/en/Publications/WEO/weo-database/2023/October>

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Asia Development Bank. (2021). Asian Development Outlook; <https://www.adb.org/publications/asian-development-outlook-2021>

Association of Southeast Asian Nations. (2024). ASEAN Economic Community; <https://asean.org/our-communities/economic-community/>

Results

The following results were obtained from the analysis. Presented in Table 4.1

Table 4.1: Results of the analysis

Consortium	Region	Membership criteria	Governance structure	Financing mechanism
CANARIE	North America	1	0	5
Internet2	North America	2	2	4
RedCLARA	South America	0	0	5
UbuntuNet Alliance	Africa	0	0	0
WACREN	Africa	2	1	1
ASREN	Asia	0	3	1
GEANT	Europe	1	0	1

NorduNET	Europe	0	0	0
CAREN	Asia	0	3	0
APAN	Asia	2	0	1

- Some consortiums offer membership only to NRENs, while others offer a range of membership categories, such as associate membership, industry partner membership, and Partner membership other than the NREN membership. The majority of regional NREN consortiums offer membership only to NRENs
- NREN consortiums are governed by a Board of Directors, a Board of Trustees, or Community Governance. Of these three models, the Board of Directors is the most popular and most practiced.
- A common mechanism of generating operating finance for all the NREN consortiums was collecting membership fees. Not limited to membership fees, on top of that, service fees are collected for the services provided among the consortium members. Some of the Consortiums formed with low and middle-income countries in Asian and African regions were formed with a grant received.
- When considering the regional context,
 - The Political Stability and Governance of American and European regions are comparatively highly stable, and the governance is favourable for consortium establishment, while it's varied in African and Asian regions because some countries of these regions have highly stable situations while some are very unstable.
 - In terms of economic factors, the American and European regions demonstrate strong economies with high-GDP countries. Asia shows a mix of low and high-GDP countries, while Africa has predominantly low-GDP countries. The American region boasts a large and open market. Asia's market size is significant, but its openness varies. The European region is composed of combined markets within the EU region, and the African region has an emerging market but with a high risk.
 - Cultural and Social Factors vary greatly across American, Asian, and African regions, with notable diversity. Diversity exists in the European region but is well integrated within the European Union. Social acceptance is usually high among the American and European regions. In Asian and African regions, it varies as some nations are more public and some are more individualistic.
 - Technological Advancement and Digital Connectivity are high in America and Europe. Asian region varies: some nations lead in technology, others are developing. East Asia has high digital connectivity; Southeast and South Asia have low connectivity. Some countries in the African region show rapid progress in technological advancement, and some show very little advancement and progress. Hence, technological advancements differ in the region, and digital connectivity is low overall.
 - When comparing Educational and Research Capabilities, leading universities are housed in the American and European regions. Hence, research output is higher in these two regions. Certain countries in the Asian region have many world-class universities, and there has been a rapid

increase in research output from this region. The situation in the African region is that there are only a few robust universities and research output is low.

Recommendations and conclusion

Providing membership for NREN members is more practical and crucial, but allocating space for a wide range of stakeholders, including NRENs, associate members, industry partners, and relevant entities, promotes a more dynamic consortium by encouraging a diverse exchange of knowledge and resources.

The Board of Directors model has proven to be the most effective and practised governance structure for NREN consortiums. It provides strategic oversight, ensures accountability, and supports decision-making processes that reflect the consortium's diverse membership.

A sustainable financial model is essential for the longevity of NREN consortiums. Collecting membership fees from member institutions and service fees for specific services provided ensures a steady revenue stream. This model can be supplemented with grants and external funding, particularly for consortiums in low and middle-income countries. Actively seeking grants from international organizations and development agencies can provide essential funding for initial setup and specific projects. This is especially important for consortiums in regions with limited financial resources.

Recognising the unique political, economic, and social contexts of different regions is critical. Consortiums should develop tailored strategies considering regional stability, economic strength, market openness, and cultural factors.

In conclusion, the success and sustainability of NREN consortiums require flexible membership options, robust governance models, and diversified financing mechanisms. Tailoring strategies to regional contexts, investing in technological and educational capacity, and fostering inclusive and participatory governance are essential to enhance research and education networks. These efforts will strengthen the consortiums and contribute to regional and global development by facilitating advanced research, education, and technological progress.

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