

CONNECTING CULTURES: A GLOBAL PERSPECTIVE ON ADVANCING WIRELESS TECHNOLOGY

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ABSTRACT

The 21st century has seen the rise of wireless technology as a technological mainstay and a cultural influence. From the analog period of 1G to the AI-native vision of 6G, this article offers a global perspective on how wireless communication has changed through the combined effects of innovation, standardization, and sociocultural adaption. Wireless technologies have influenced cross-cultural interaction, digital inclusion, and economic empowerment in addition to facilitating ubiquitous connectivity. Through regional turning points like Africa's M-PESA innovation, India's CDOT rural systems, Japan's leadership in mobile internet, and Europe's GSM standards, we highlight how local settings impacted global advancement. The study also looks at how important it is for international organizations like the IEEE, ITU, and 3GPP to harmonize frequency policies and technical standards in order to facilitate interoperability across borders. Research and development initiatives that span cultures, including Hexa-X, the Open RAN Alliance, and the U.S.-India 5G partnership, demonstrate how diversity spurs innovation and policy convergence. We also demonstrate how wireless technologies serve as cultural bridges by facilitating language preservation, digital storytelling, mobile education, and religious participation. Our contributions consist of a socio-cultural study, a worldwide

historical synthesis, and practical policy suggestions for fair 6G development. We reinterpret wireless technology's capacity to bring societies together by considering it as a bridge of cultures and values as well as a system of signals and protocols. The article promotes inclusive frameworks that find a balance between sensitivity and scalability, ethics and innovation, and international cooperation and local empowerment.

KEYWORDS

Wireless Communication · Cultural Integration · Global Standards · 6G · Digital Inclusion · Innovation Policy · Technology Diplomacy.

1. INTRODUCTION

Around the globe, the development of wireless communication technology has drastically changed how people interact, cooperate, and communicate. From the late 19th century, when Guglielmo Marconi invented wireless telegraphy, to today's ultra-fast 5G and developing 6G networks, wireless systems have continuously broken down barriers—not just of speed and distance, but also of socioeconomic and cultural divides [1]. From 1G's analog voice, 2G's digital SMS, 3G's mobile internet, and 4G LTE and 5G's ultra-low latency and huge connection, each generational leap has been influenced by regional demands, cultural norms, and global cooperation in addition to technological improvements. This is furthered by the current 6G concept, which places a strong emphasis on sustainability, intelligent connection, and the integration of communication, computing, and sensing [2], [3]. International cooperation has been essential to this endeavor. Interoperability across borders has been made possible by the standards established by groups such as the International Telecommunication Union (ITU), 3GPP, and IEEE. Multinational partnerships are essential for the development of scalable, inclusive, and culturally adaptive technologies, as evidenced by joint research and development (R&D) projects like Horizon Europe, 6G Flagship (Finland), and US-India 5G cooperation [4], [5]. Additionally, knowledge sharing between industry and academia promotes technical diplomacy, speeds up innovation, and helps close regional gaps. According to this research, wireless technology serves as a bridge among cultures even though it is frequently thought of as a technical discipline. For example, mobile internet has enabled remote tribal communities to participate in digital economies, while global platforms like TikTok, WhatsApp, and YouTube allow real-time cultural exchange, enabling people in vastly different social contexts to learn from and influence each other. Moreover, culturally sensitive technology design (e.g., user interfaces in local languages or mobile payment systems for unbanked populations) is critical for digital inclusion.

This paper presents a global perspective on the socio-cultural dimensions of wireless communication, emphasizing how regional diversity contributes to innovation, shapes technology adoption, and necessitates collaborative governance. Specifically, we make the following contributions:

1. We provide a historical analysis of wireless communication evolution through a global lens, highlighting contributions from different regions.
2. We explore how culture and regional needs influence wireless system design and usage.
3. We examine international standardization efforts and regulatory alignments, showcasing how policy harmonization supports global interoperability.
4. We analyse the role of cross-cultural collaboration in R&D, emphasizing innovation through diversity.
5. Finally, we propose policy and design frameworks that respect cultural nuances while promoting technological equity in the future 6G era.

2. HISTORICAL EVOLUTION OF WIRELESS TECHNOLOGY

The development of wireless communication has been a cornerstone of modern connectivity, driven by a series of technological milestones and global collaborations that continue to reshape human interaction. The journey from 1G to the forthcoming 6G encapsulates more than just generational technical upgrades; it reflects the growing integration of international cooperation, cultural diversity, and localized innovation in shaping communication systems.

The roots of wireless communication trace back to Guglielmo Marconi, who successfully demonstrated long-range wireless telegraphy in 1895, culminating in the first transatlantic wireless transmission in 1901. This breakthrough laid the foundation for global wireless systems and inspired early innovations in analog radio communication [6]. Subsequent decades witnessed major contributions from various regions. For example: Japan's NTT (Nippon Telegraph and Telephone) launched the first commercial 1G cellular network in Tokyo in 1979, pioneering mobile voice services. In Europe, the establishment of the GSM (Global System for Mobile Communications) standard by CEPT and ETSI in the 1980s set the stage for 2G digital voice and SMS services [7].

India's CDOT (Centre for Development of Telematics) played a vital role in extending affordable rural telecommunications in the 1980s, designing switching systems tailored to regional infrastructure needs [8]. These regional breakthroughs collectively contributed to the global expansion of wireless systems and highlighted the significance of local innovation in addressing diverse challenges. Table 1 shows the evolution from 1G to 6G with its technical features.

Table 1. Evolution from 1G to 6G: technical and societal features.

Generation	Timeframe	Key Features
1G	1980s	Analog voice communication (e.g., AMPS, NTT). Limited coverage and poor security [9].
2G	1990s	Digital communication (GSM, CDMA), SMS, better call quality and encryption [10].

3G	2000s	Mobile Internet (UMTS, EV-DO), video calls, basic web access [10].
4G	2010s	LTE, VoIP, HD streaming, mobile apps, cloud access [9].
5G	2020s	eMBB, URLLC, mMTC, smart cities, high-speed and low-latency connectivity [9].
6G	2030s (vision)	AI-native, THz, ISAC, tactile internet, metaverse, ubiquitous intelligent systems [9].

3. CULTURAL AND REGIONAL INFLUENCES

Diverse global contexts yield varying use-cases and adoption patterns. In Africa, mobile banking through M-PESA reflects both necessity and innovation. Meanwhile, Japan pioneered mobile internet long before it was common globally. Cultural preferences, literacy levels, and urbanization influence everything from UI design to data usage policies. Table 2 presents region-specific innovations and cultural influence.

Table 2. Region-specific innovations and cultural influence.

Region	Innovation	Cultural/Strategic Context
Africa	M-PESA mobile payments	Leapfrogged fixed-line; enabled financial inclusion in unbanked populations [11].
Japan	Mobile TV, QR codes	Early adopter culture, compact design preferences [11].
India	CDOT rural switching systems	Affordable telecom infrastructure for underserved areas [11].
China & S. Korea	5G leadership	National investment, industrial policy, global export focus [11].

Wireless technology adoption and innovation are not uniform across the globe—they are deeply shaped by regional priorities, cultural preferences, socioeconomic contexts, and government strategies. While the technological backbone of mobile networks is globally standardized, the ways in which societies use, adapt, and expand wireless communication are uniquely local [11].

3.1 Socio-Cultural Drivers of Technology Usage

In technologically advanced societies, wireless technologies are integrated with emerging services like AI-based personal assistants, e-health monitoring, and digital identity platforms. In contrast, developing

regions have often used wireless systems to leapfrog infrastructure gaps—such as introducing mobile money services in areas lacking traditional banking [11].

Cultural factors influence both the form and function of wireless systems: In Japan, societal emphasis on compact, efficient devices led to early adoption of camera phones, QR codes, and mobile payments. In India, a large multilingual population pushed telecom providers to offer voice assistants and applications in local languages. In Nordic countries, cultural values around privacy accelerated the adoption of encrypted mobile messaging and digital ID systems. In Sub-Saharan Africa, necessity drove innovation—mobile platforms like M-PESA became essential tools for financial inclusion [11]. These examples reflect how local values and challenges shape wireless technology’s design, deployment, and usage.

3.2 Urban-Rural Divide and Local Adaptations

Urban environments often benefit from early rollouts of high-speed wireless networks due to high population density and commercial viability. However, rural and remote areas present unique challenges: lack of power infrastructure, lower income levels, and limited technical literacy. In response, solutions like community-owned cellular networks, low-power IoT mesh systems, and satellite internet access have gained momentum in various regions [11]. Additionally, the digital gender divide—where women in many regions have less access to mobile devices and services—demonstrates that cultural norms influence not just access to technology, but its equity of impact [11].

4. GLOBAL STANDARDIZATION AND POLICY

International standardized frameworks and coordinated policy objectives are essential to the development and scalability of wireless communication systems. These international standards guarantee smooth interoperability, security, and spectrum efficiency, allowing infrastructure and mobile devices from various manufacturers and geographical areas to work together seamlessly worldwide.

Important organizations like the International Telecommunication Union (ITU), the Third Generation Partnership Project (3GPP), and the Institute of Electrical and Electronics Engineers (IEEE) have been leading intensive cross-continental coordination efforts to meet the increasing demand worldwide and guarantee fair access to spectrum and infrastructure. Setting technical requirements, frequency distributions, and compliance guidelines for wireless technology throughout generations depends on these organizations.

Furthermore, regional policy frameworks that illustrate how cultural and legal norms impact wireless regulation and uptake include China’s National Informatization Strategy, India’s Digital Communications Policy, and Europe’s GDPR. Institutions like the ITU, IEEE, and 3GPP are essential for coordinating international wireless initiatives. Regulation is also influenced by cultural factors; for example, the U.S. prioritizes market-driven innovation, whereas Europe prioritizes privacy through

GDPR-compliant wireless networks. An important step toward democratized, interoperable infrastructure is the emergence of Open RAN. The role of global standard organizations is represented in Table 3.

Table 3. Global standards organizations and their roles.

Organization	Responsibilities and Impact
ITU	Defines global spectrum allocations; sets IMT standards for mobile networks [11].
3GPP	Develops mobile protocol standards like LTE and 5G NR through multi-region partnerships [11].
IEEE	Publishes 802 standards (e.g., 802.11 for Wi-Fi, 802.15 for Zig-Bee/Bluetooth) [11].
CEPT/ETSI	Created GSM standard; leads European regulatory and technical standards [11].

4.1 Socio-Cultural Drivers of Technology Usage

One of the most important aspects of standardization is the harmonization of spectrum usage. Spectrum is a finite resource, and its efficient global allocation reduces interference and facilitates cross-border roaming and equipment compatibility. The ITU’s World Radio Communication Conferences (WRC) are critical events where countries negotiate and align on frequency band usage (e.g., 700 MHz for LTE or 26 GHz for 5G mm Wave). Regional regulators like the FCC (USA), TRAI (India), MIIT (China), and Ofcom (UK) then interpret these global guidelines and set local licensing policies, leading to both convergence and diversity in deployment strategies.

4.2 Policy and Governance Differences by Region

Cultural and legal frameworks play a critical role in how wireless technologies are adopted and governed. Table 4 has been displaying the regional policy approaches and cultural priorities.

Table 4. Regional policy approaches and cultural priorities.

Region	Regulatory Focus	Cultural/Policy Highlights
Europe	Privacy, Open Access	GDPR-driven data handling; strict cross border spectrum coordination via CEPT and ETSI.
USA	Market-led Innovation	FCC auctions; industry-driven deployment of spectrum and infrastructure; net neutrality debates.
China	National Strategic Control	MIIT-led spectrum assignment; heavy investment in domestic 5G/6G manufacturing and export.
India	Inclusive Access, Digital Uplift	TRAI policy for rural coverage and affordability; spectrum reserve pricing and tech neutrality.
Africa	Leapfrog Connectivity	Focus on shared infrastructure, digital inclusion; ITU and GSMA-supported regional harmonization.

4.3 Emerging Directions

For future 6G systems, global policy coordination will require:

1. Ethical frameworks for AI-native wireless systems
2. Decentralized spectrum access (e.g., shared or cognitive spectrum)
3. Unified security standards for data integrity and sovereignty
4. Cross-border experimentation zones and testbeds

Additionally, Open RAN is emerging as a standardized, vendor-neutral approach to building mobile networks, supported by alliances across North America, Europe, and India.

5. CROSS-CULTURAL COLLABORATION AND INNOVATION

The advancement of wireless communication technology has been fueled not only by engineering breakthroughs but also by deep-rooted cross-cultural collaborations across governments, academia, industries, and standardization bodies. In an increasingly interconnected world, innovation in wireless systems—from 5G to 6G and beyond—thrives on the diversity of thought, regional priorities, and shared knowledge emerging from collaborative networks that span continents [12]. Collaboration across borders allows countries to pool resources, share spectrum policies, align hardware development, and tackle joint challenges such as network scalability, spectrum efficiency, and secure architectures. Diverse perspectives stimulate creativity, ensuring that solutions are inclusive and adaptable across varying economic, social, and technological landscapes [13]. Cross-cultural teams composed of researchers from Europe, Asia, Africa, and the Americas bring domain-specific knowledge—ranging from rural connectivity strategies to high-density urban spectrum reuse. These collaborations also help address ethical and cultural considerations in areas like data privacy, interface design, and localization for example, multilingual AI assistants or local-language interfaces for mobile applications stem from culturally diverse teams understanding user behavior in different contexts [14].

Localized innovation: Region-specific solutions for deployment (e.g., RIS on walls in urban India vs. drone-assisted networks in Africa) [16].

- User-centric design: Culturally aware UI/UX for varied literacy levels and habits.
- Policy alignment: Negotiated data privacy and security expectations between continents.
- Distributed workforce development: Global upskilling through shared PhD programs and exchanges (e.g., EU–ASEAN mobility schemes) [14].

Table 5 highlights major global efforts contributing to wireless innovation through cross-cultural cooperation: Cultural diversity fosters:

Table 5. Cross-cultural collaboration in wireless innovation.

Initiative/Project	Participating Regions	Focus Area / Contribution
Horizon Europe – Hexa-X	EU, Japan, Korea	6G vision, sustainable networks, RIS, edge AI integration [15]
6G Flagship (Finland)	Finland, Global Partners	AI-native networking, mmWave, energy-efficient design [16]
Open RAN Alliance	US, India, UK, Germany	Interoperable hardware, vendor diversity, joint testbeds [15]
ITU-R WP5D (IMT-2030)	Global – 193 nations	6G standard setting, spectrum alignment, policy dialogue [16]
NSF–India Joint Research	US, India	Open RAN, IoT testbeds, spectrum sharing, rural broadband [15]
RISE-6G Project)	(EU Italy, France, Germany, Spain	Reconfigurable Intelligent Surfaces (RIS) for green 6G [15]
WWRF – Wireless World Research Forum	100+ countries	Global roadmap coordination for post- 5G and 6G [16]

These outcomes help ensure that emerging wireless technologies are both globally viable and locally effective. For instance, Horizon Europe and the 6G Flagship project in Finland involve multi-country consortia tackling AI-native networks, green communication, and Terahertz systems [16]. The U.S.–India initiative on Open RAN promotes open interfaces and vendor-neutral platforms through joint testbeds and university cooperation. In the Asia-Pacific region, Japan, China, and South Korea lead with standardization research and early 6G trials while actively participating in ITU-R Working Party 5D. Such cooperative frameworks enable not only technology co-development but also the harmonization of policies, testing infrastructure, and human capital exchange [16].

6. WIRELESS TECHNOLOGY AS A CULTURAL BRIDGE

Wireless communication fosters global dialogue, digital diplomacy, and cultural exchange. Platforms like TikTok, WhatsApp, and YouTube transcend borders, enabling users from rural villages to urban cities to share, learn, and collaborate. Technologies like RIS and satellite internet bridge the digital divide, offering equal access to information and education.

Table 6 shows Wireless technology has become a powerful cultural bridge by enabling real-time global exchange, preservation of local identities, and inclusive access to resources. Platforms like YouTube, TikTok, and Instagram Reels allow individuals from remote or marginalized regions to share traditional music, dances, and stories with a global audience, democratizing cultural narratives and preserving

indigenous identities through digital storytelling [17], [18]. Language translation and learning apps such as Google Translate and Duolingo support cross-cultural communication while also preserving endangered languages by enabling their digital presence [19], [20]. In education, mobile-based platforms—including MOOCs, WhatsApp classrooms, and e-book libraries—have expanded access to localized learning, especially in rural or nomadic communities during crises like COVID-19 [21]. In the healthcare domain, mobile health (mHealth) tools like SMS helplines and telemedicine reduce cultural and geographical barriers, empowering women and underserved populations to access care and information [22]. Wireless technology has also enabled diaspora communities to maintain spiritual ties through live-streamed religious services and mobile religious apps, fostering a sense of global belonging [23]. Moreover, tools like Zoom and UN-hosted webinars support digital diplomacy and cross-border humanitarian collaboration during crises [24].

Table 6. Roles of wireless technology in bridging cultures.

Domain	Examples of Wireless Use	Cultural Impact
Digital Storytelling	YouTube, TikTok, Instagram Reels	Spread of indigenous dances, food culture, fashion; real-time global audience
Language	Mobile apps (Google Translate, Duolingo)	Enables communication across linguistic divides; supports endangered language preservation
Education	Mobile MOOCs, WhatsApp schools, e-books	Learning in local languages; access for rural/nomadic communities
Healthcare	mHealth services, SMS helplines, telemedicine	Cultural barriers reduced for remote health access; women’s health awareness
Religious	Live-streamed prayers, Quran/Bible apps	Global diaspora connection to home traditions and beliefs
Digital Diplomacy	Zoom diplomacy, UN webinars, NGO coordination	Humanitarian support and international collaboration in crises
Economic Empowerment	Mobile banking, micro entrepreneurship via WhatsApp	Uplifts local crafts, services, especially for women and artisans

Finally, mobile banking and platforms like WhatsApp empower local artisans and entrepreneurs—particularly women—to engage in economic activities that uplift their communities through digital

inclusion [25]. As these examples show, wireless connectivity not only transforms technical infrastructure but also serves as a vital instrument of cultural empowerment and mutual understanding.

7. CHALLENGES AND BARRIERS

Despite progress, gaps remain. Digital literacy, infrastructure disparities, and economic inequality hinder universal wireless adoption. Cultural resistance to new technologies (e.g., older populations, rural communities) must be addressed through inclusive design, community outreach, and education. Harmonizing security perceptions also remains a global challenge.

Table 7. Summary of key barriers in advancing wireless technology.

Challenge Category	Description / Impact
Infrastructure Gap	Lack of coverage in rural/remote areas due to cost and terrain issues.
Digital Literacy	Users lack skills to use smartphones and digital services.
Spectrum Fragmentation	Non-uniform spectrum allocation delays interoperability and 5G/6G rollout.
Security & Privacy	Data theft, spoofing risks, and lack of unified privacy regulations.
Affordability	Devices and data plans are too expensive in many developing regions.
Cultural Resistance	Technophobia, misinformation, or lack of trust in institutions hinder adoption.

Table 7 presents a consolidated overview of the primary barriers hindering the equitable advancement of wireless technology. One of the most pressing issues is the persistent infrastructure gap, particularly in rural and remote areas, where the high cost of deployment and geographic challenges limit network expansion [26]. Digital literacy remains another significant hurdle, with large segments of the population—especially in developing nations—unable to effectively use mobile devices and online platforms, limiting the societal benefits of wireless connectivity [27]. Spectrum fragmentation across countries impedes global interoperability, slowing the rollout of technologies like 5G and emerging 6G networks. Concerns around security and privacy, including unauthorized data access and inconsistent global privacy regulations, further undermine user trust [28]. Meanwhile, economic constraints—such as the high cost of smartphones and data plans—prevent billions of people from accessing mobile broadband, even where coverage is available [26]. Finally, cultural resistance driven by misinformation, surveillance fears, or distrust in institutions can significantly delay technology acceptance and adoption [29]. Addressing these challenges is crucial for building an inclusive and truly global wireless ecosystem.

8. FUTURE OUTLOOK AND POLICY RECOMMENDATIONS

As 6G looms, it’s vital to integrate cultural inclusivity into R&D frameworks. Policies should support open innovation, global talent mobility, and data sovereignty. AI-driven personalization must respect cultural sensitivities. Future technologies should not just connect devices, but also connect values, communities, and ideas. The next decade promises a transformative shift in wireless communication, particularly with the emergence of 6G and AI-native networks. As wireless systems become more intelligent, immersive, and pervasive, ensuring that they are culturally inclusive, ethically grounded, and globally cooperative becomes critical. This section outlines both visionary directions and actionable policy strategies to guide wireless development with a global and human-centered approach.

8.1 6G and Beyond: Vision for an Intelligent, Inclusive Future

6G is envisioned as a foundational pillar of ubiquitous connectivity that integrates the physical and digital worlds. It is expected to support:

- Intelligent connectivity: Seamless integration of AI, sensing, and communication technologies.
- Human-centric services: Prioritizing quality of experience, privacy, and inclusivity.
- Sustainability: Minimizing energy consumption through green architectures.
- Universal access: Bridging rural-urban divides and reaching underserved populations.

Such ambitions require coordinated global efforts to align technology with equitable policy frameworks.

8.2 Policy Recommendations for Global Collaboration

Global collaboration will be key to future wireless success. Table 8 below outlines actionable policy recommendations that can be implemented across research, industry, and governance domains.

Table 8. policy recommendations for future wireless development.

Policy Domain	Focus Area	Recommended Actions
Standardization	Inclusive Protocols	Include emerging economies and diverse stakeholders in 6G standard bodies (ITU, 3GPP).
Research & Innovation	Global Talent Exchange	Fund cross-border fellowships and multinational pilot projects (e.g., RIS, AIoT).
Digital Inclusion	Rural Connectivity	Subsidize infrastructure for remote areas using RIS, satellite backhaul, and solar powered BS.
Data Sovereignty	Privacy Regulations	Develop interoperable data governance frameworks respecting

		cultural norms (e.g., GDPR-style policies).
Sustainability	Green Networks	Promote circular hardware economy, spectrum sharing, and AI-based power saving.
Education	Tech Literacy	Integrate 6G and IoT awareness in schools and community programs. Local-language content platforms are essential.

8.3 Toward a Globally Harmonized Wireless Future

To build a resilient and culturally aware wireless future, nations must move beyond isolated deployments toward:

- Open Innovation Ecosystems: Open-source platforms, shared testbeds, and collaborative IP models.
- Federated AI Systems: Decentralized training with local data to avoid surveillance and bias.
- 6G Ethics Councils: Multi-stakeholder bodies to monitor societal impacts, fairness, and access.
- By anchoring wireless evolution in diversity and collaboration, the future of global communication can be one of empowerment, equity, and sustainable innovation.

9. CONCLUSIONS

More than just a communication infrastructure, wireless technology has developed into a cultural and economic facilitator that is revolutionizing the way civilizations interact, exchange, and advance. This study has emphasized that the global evolution of wireless systems, from 1G to the next 6G, is a collaborative and culturally entrenched evolution rather than just a linear increase in speed and efficiency. We show through historical mapping how many regions, such as China, Japan, Europe, India, and Africa, have made distinct contributions to the wireless landscape, frequently forming systems according to regional socioeconomic requirements. The results highlight the importance of cultural preferences and regional innovation in the development, uptake, and effects of wireless technology. The research also emphasizes how important international standards organizations like the ITU, IEEE, and 3GPP are to guaranteeing cross-border deployment, spectrum coordination, and interoperability. For global scale-up, they play a crucial role in striking a balance between regional flexibility and technological uniformity. Important revelations also highlight the importance of cross-cultural cooperation in R&D, as demonstrated by 6G research alliances and Open RAN, in bridging digital barriers and promoting inclusive innovation. Wireless devices are becoming more and more platforms for digital empowerment and cultural expression, overcoming barriers related to opportunity, language, and geography. In conclusion, cultural sensitivity, ethical governance, and equity must all coexist with the advancement of wireless communication. A more connected and cohesive world as

well as intelligent networks will be shaped by embracing diversity and promoting international cooperation as we advance toward 6G and beyond.

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Authors Contributions (Compulsory):

Hasit B. Mehta: Conceptualized the study, designed the methodology, and led the manuscript writing and overall supervision of the research. **Harishkumar B. Chaudhari:** Contributed to data collection, performed the formal analysis, and assisted in drafting the results and discussion sections. **Vishalkumar Mandalika:** Responsible for literature review, data interpretation, and editing the final draft of the manuscript. **Sagarkumar Patel:** writing article and performed statistical analysis, and contributed to the visualization of the results. **Dharmendra Chauhan:** Involved in data curation, validation of results, and helped revise the manuscript critically for important intellectual content. **Hardik Modi:** Supported in helped with reference management, and contributed to proofreading and formatting the paper.

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