

Mobile (wireless) telecommunication sector: an Indian perspective and PESTLE analysis

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Abstract—Revolutionary changes in how people interact while travelling at a distance have given rise to several mobile communication tactics. Numerous generations of Mobile telecommunications/telephony have progressed as 1G, 2G, 3G, 4G, 5G, and 6G (now under research). However, in the context of India, mobile telephony can be realized from 2G. The sector has directly or indirectly been impacted by political, social, economic, technological, legal, and environmental (PESTLE) aspects. Therefore, the study objectives are first to discuss the (mobile) telecom sector evolution outline and, second, the factors that contributed to sectoral development by the PESTLE framework. The conceptual foundation of the work is secondary sources.

Keywords—1G; 2G; 3G; 4G; 5G; Indian Telecom Sector; mobile communication; PESTLE

I. INTRODUCTION

THE global telecommunications markets have transformed because of modern communication technology. India's telecom sector has been growing significantly since the 1990s. The modern world has been greatly influenced by telecommunication, which is now embedded in every Indian. The industry has evolved significantly in terms of lowering transaction costs, boosting internet speed, enabling free calls across India, and altering the services, societies, and brands lifestyles.

In India, the industry is moving towards utilizing the 5G technology. Both the market structure and operator competitiveness have undergone significant change. India has the world's fastest-growing mobile device market. The consumer and governmental markets for telecom services in India are healthy.

With a growth rate of 0.17%, monthly the total number of wireless subscribers climbed at the end of February 2023 from 1,141.96 million to 1,143.93 million, where within the Urban wireless subscriptions from 626.37 million to 627.54, and rural wireless subscriptions from 515.60 million to 516.38 million at the March 2023 end with wireless subscription growth rates for rural and urban areas were 0.19 and 0.15, monthly respectively. In addition, the overall India's Wireless Tele-density has also changed from February 2023 end from 82.38% to 82.46%, where within urban Wireless Teledensity from 128.41% to 128.45% and Rural Tele-density from 57.39% to 57.46% at March 2023 end. However, the urban and rural wireless

subscribers accounted for 54.86% and 45.14% of all wireless subscribers, respectively, at the end of March 2023 [1].

Moreover, Telecom companies introduced a 4G network in 2012, but with the entrance of Jio operator in the market, has changed the structure not only in terms of their capital structure through Mergers and Accusation but also in data, call rates, connectivity, and speed. India experienced significant growth in recent years and has surpass as the second-largest telecoms market from the United States in the world in December 2022 with 1,170.38 million subscriber base. A report by the GSM Association (GSMA) and Boston Consulting Group (BCG) claims that India's rapidly expanding mobile economy would have a significant impact on the country's GDP [2].

Because the government implemented the telecom reformation programme, telecom sector has undergone tremendous transformation over time. A new telecom law, the National Digital Communication Policy of 2018, was created taking into account cutting-edge features like 5G, machine-to-machine communication, and the IoT (Internet of Things). The telecom industry has also introduced "customer-focused" and "application-driven" methods in order to deliver these services, better serve the nation, and craft a solid basis for Digital India.

As per the GSMA report 2022, there was a look at the Indian mobile telecom market, where significant growth and its movement towards the digital nation could be seen, followed by the mobile at the heart of the telecommunication and as the backbone of digital India (refer to figure 1) [3].

	2015	2022
Unique mobile subscribers	587m	770m
CAGR: 4.0 %		
SIM connections	1.0bn	1.1bn
CAGR: 1.4 %		
Mobile Internet users	290m	557m
CAGR: 9.8 %		
Smartphone Adoption	21 %	77 %
Technology	2G: 85%	2G: 18%
	3G: 14%	3G: 3%
	4G: 1%	4G: 79%
Operators' Revenues and Investment (2015-2022)	Total Revenues: INR 14.4tn Operator Capex: INR 4.4tn	
Mobile industry contribution to GDP	INR 10.8 trillion, 4.75% of GDP	
Public funding	Mobile ecosystem contribution to public funding in 2021 (before regulatory and spectrum fees) INR 1.4 trillion	
Employment	Job supported by the mobile ecosystem in 2021 3.4 million direct jobs and 1.3 million indirect jobs	

Fig.1. Indian (Mobile)Telecom Sector Market at Glance

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Henceforth, in this paper authors conducted a PESTLE analysis to evaluate the political, social, economic, technological, legal, and environmental aspects that trails the sectoral development. The development of PESTLE analysis dates back more than 50 years, to the American professor Francis Aguilar, whose specialty was strategic planning. The PESTLE tool was initially found in Aguilar's book *Scanning the Business Environment*, which was released in the late 1960s. However, initially it was not known as a PESTLE analysis, it was called a PEST. The tool has had several names over the years using slightly different acronyms, including (Refer Figure 2) [4]- [5].

However, initially it was not known as a PESTLE analysis, it was called a PEST. The tool has had several names over the years using slightly different acronyms, including:

PEST – This stands for Political, Economic, Sociological, Technological. This was the initial acronym that was found in Aguilar's book.

STEP – This is the PEST acronym, but displayed in a different order.

STEEPLE – This is an addition to the PESTLE, including an extra E which stands for Ethical.

SLEPT – This is a reduction to the PESTLE, removing the Environmental category.

STEPE – This is a reduction to the PESTLE, removing the Legal category.

PESTLIED – This is an addition to the PESTLE, including International and Demographic.

LoNGPESTLE – This is an extended version of the PESTLE. The LoNG acronym at the beginning stands for Local, National and Global.

Fig.2. Various Terminologies names over the years

The paper is structured as follows: it starts with Section 1 as an introduction; Section 2 defines the Indian (Mobile)Telecom Sector. Section 3 is an overview of the research methodology approach. In Section 4, analysis and discussion is done based on the PESTLE approach and concluded in Section 5.

II. INDIAN (MOBILE) TELECOMMUNICATION SECTOR

Our daily lives have been drastically changed by the arrival of cell phones and internet services, where a person's life depends on their mobile phone and the services it offers. Since liberalization and privatization, India's mobile communication industry is viewed as one of the more efficacious stories to have come out of India. The fact that the nation offers the most affordable modern telecom services anywhere in the globe and that there are 0.06 telephones per 100 people in the country than there were in 1991—82.46 phones per 100 people in March 2023—indicates this. The industry is becoming a crucial factor in India's GDP expansion. A sizable domestic market for telecom equipment as well as the numerous kinds of electronic components and semiconductor devices used in its production is being created by the growth of the telecom services market [6], [7].

The worldwide development of mobile telecommunication systems started from 1G as analogue communication and then radically moved towards 2G as digital communication. From where the journey of data, voice, and their convergence begins. Whereas, in the Indian context, the journey of mobile telephony is very interesting. The country skipped the 1G services of the

1980s, jumping straight to GSM 2G digital communication. With the outline of the first mobile service in India, "Modi Telstra," in Calcutta in 1995, the first call was made. Cell phones costing roughly Rs. 40,000 and the call rate structure, which charges Rs. 16 for outgoing calls and Rs. 8 for incoming calls, were the main reasons why cellular communication did not gain the expected level of popularity [8], [9].

Market transformation, network expansion, and astounding growth were all made possible by technological advancement and a supportive policy environment. There were thirteen private mobile service providers in 1999 with 2G technology, the year when the NTP (National Telecom Policy) was made public. By 2023, there were only four large operators left after exits and amalgamation. With 4G technology securely installed in all private networks and the debut of 5G services in October 2022, telecom networks are presently the basis of India's digital economy. The COVID-19-related national lockdown demonstrated how crucial communications are to maintaining economic activity and enhancing its growth implications. As per various reports, the sector contributed more to India's GDP at that time [9].

Through their research publications, books, blogs, and white papers, a large number of authors have contributed to the research effort in the telecom sector. Following that, the antiquity of Indian telecom began in 1851 when the government set up the first operable landlines near Calcutta (the seat of British administration). In 1881, the first telephone service was presented. In 1883, the telephone and postal systems were merged. IRT (Indian Radio Telegraph Company) was founded in 1923. All foreign telecommunications companies were nationalized after the nation's declaration of independence in 1947 to form the PTT (Posts, Telephone, and Telegraph), a monopoly under the jurisdiction of the Ministry of Communications. The government believed it was best to have governmental control over the telecom industry since it was seen as a strategic service.

The first wave of industry changes began to blow when the private sector was approved for telecommunications equipment manufacturing in the 1980s. The DoT came into existence in 1985. It was an independent, specialized domestic and international service provider with its own regulating authority. In 1986, the VSNL (Videsh Sanchar Nigam Limited), and MTNL (Mahanagar Telephone Nigam Limited), were recognized to provide urban service in urban areas, and international telecommunications respectively. The government owns all shares of both businesses. In the 1990s, the telecommunications industry profited from the overall opening up of the economy. Additionally, officials in India took action after seeing how the telecom revolution in other nations improved service quality and reduced costs. As a result, the telecom services sector was unlocked to the private sector.

The NTP of 1994 represented the initial effort to provide the Indian telecoms sector thorough roadmap. India's TRAI (Telecom Regulatory Authority) was recognized in 1997 to serve as a regulator and promote the telecom industry's expansion. Cellular services were introduced in 1999, the same

year that the New National Telecom Policy was enacted. Later for managing Disputes, TDSAT (Telecommunications Dispute Settlement and Appellate Tribunal) took over from TRAI the disputes and adjudicatory functions. was formed in 2000. As technological advancement was taking place, reforms were also happening. In that step, NTP 2012 was formulated, followed by NDCP- 2018, focusing on the digital aspect. Later, in 2022, the draft of the Telecommunication Bill came for recommendation.

Initially, the telecom services available in India included-Basic Fixed Line Services; Pager Services; Mobile Services (GSM & CDMA); Internet Services; National Long Distance (NLD) Services; and International Long Distance (ILD) Services; However, in the current context, this has been described in 3 segments: Mobile (wireless); Fixed-line (wireline), and Internet services [10] – [31] The number of subscribers (wireless plus wireline), tele-density in Figure 3 [29], the status of current operators (Private and PSUs) in Figure 4 [30], and the overall journey of Mobile Telephony in Figure 5 [8] are shown respectively.

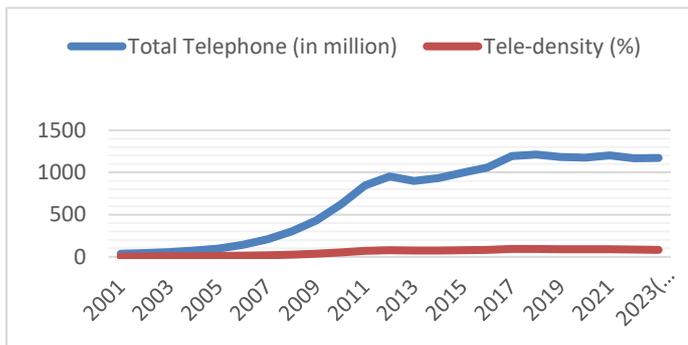


Fig.3. The trend of total telephones and tele-density (2001-2023)

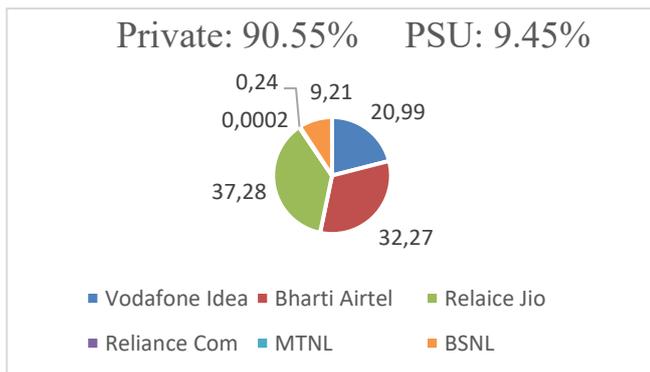


Fig. 4. Key Players and Market Share in the telecom sector

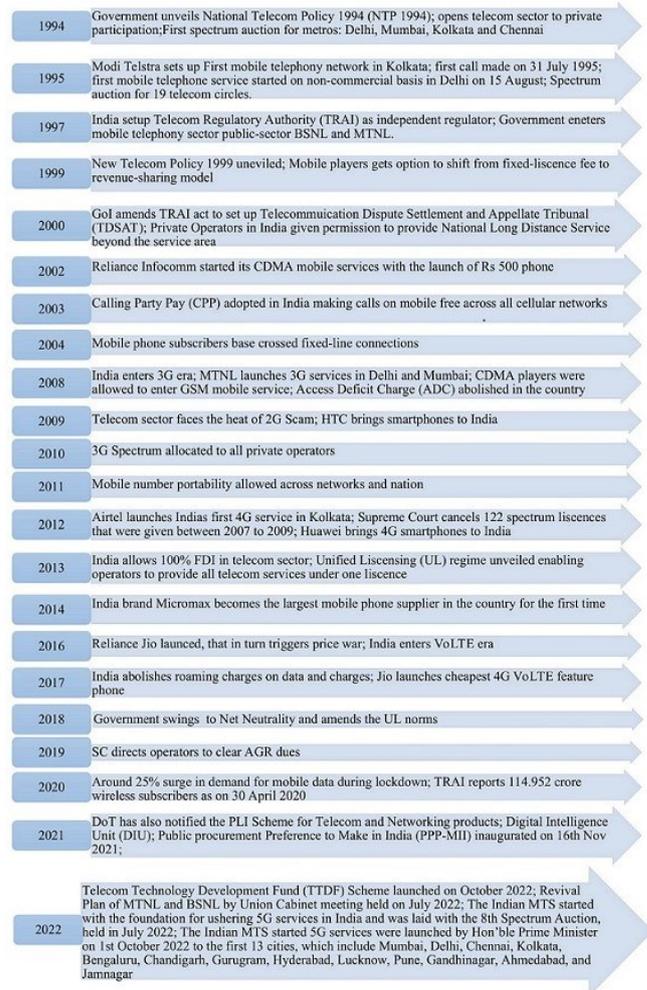


Fig.5. Evolution of Mobile Telephony (Indian (mobile) telecom sector) in India

III. RESEARCH METHODOLOGY

The study is mainly conceptual. The initial goal of this article is to trace the development of the Indian mobile (wireless) telecommunications industry. Second, a PESTLE framework was used to assess the various parameters as political, economic, social, technological, legal, and environmental factors played a part in the Indian telecom sector development. The researcher relied on books, journals, websites, editorials, and reports that have been published as secondary sources.

IV. ANALYSIS AND DISCUSSION

A PESTLE analysis is a tool or framework “used to analyze and monitor the external environment factors that impact an organization. PESTLE in reference to the acronym formed by the initials of the six categories of macroeconomic variables included in the model (Political, Economic, Socio-cultural, Technological, Legal and Environmental)”. The models take into account key aspects in the external environment and

appraise each of them to form conclusions about industry attractiveness and market potential, to determine current market and industry performance, and to predict market or industry key success factors and trends for future growth and success [32], [33]. Henceforth, the researchers use this tool to analyze the Indian Mobile Telecom Sector.

A. Political

Political instability is rife in India. any time the government changes, its policies vary as well, which hinders the operation of any industry, including the telecom sector. Any company that wishes to grow its operations, say outside of the country, must research the political climate in that nation because it will have an impact on how that nation's business operations will operate.

The political conditions in this aspect could be seen in two industrial regimes comprising products and services (such as towers, spectrum, switches, cable, wireless, wireline, devices, voice, data, Value Added Services (VAS), NLD, ILD, enterprises, and so) (based on Fransman, 2001 work [34]). First is the Old regime, where the government monopoly is found. At that time, the establishment of DoT, C-DoT, MTNL, and VSNL took place. Within the Department of Telecommunication was the main controlling body, and the innovation or research and development took place at the government research laboratories, and the telecom operators had to work according to that only, due to which the innovation process was slow and sequential. After the liberalization, when the entry of private players was allowed, that, in turn, enhanced the innovation process not only in the form of innovative technologies but also in the form of services and product domains. In this, the innovation process was dynamic, a lot of R&D started, and the new technologies got entered, first in the form of niches and then entered the regimes and stabilized. Several technical and policy-level modifications were made to increase teledensity, rural coverage, service quality, and broadband across the nation during each period (refer to Figure 6).

At least after three decades of independence, the telephone was a luxury item and at a low priority. Only it was during the Sixth Five Year Plan (FYP) that the telecommunications for rural services areas were mentioned [35]. The telephone was not seen as an ordinary object in India until the middle of the 1990s. it was later the liberalization the new private players in the market were allowed. After that, the NTP 1994 was created to maximize coverage in rural India, offering everyone access to inexpensive telecom services, making India a manufacturing hub and a significant exporter of telecom equipment, and defending the national interest in defence and security. Because of the slow growth rates and the necessity for stronger policy planning to support growth and uphold the interests of the country, the new telecom policy that is NTP-99 created focusing on the operator's benefit in terms of connecting and sharing of infrastructure, their license and license fees payment. Followed by the formation of the TDSAT to arbitrate any disputes between (a) the licensors and licenses, (b) service providers, and (c) service providers and groups of consumers.

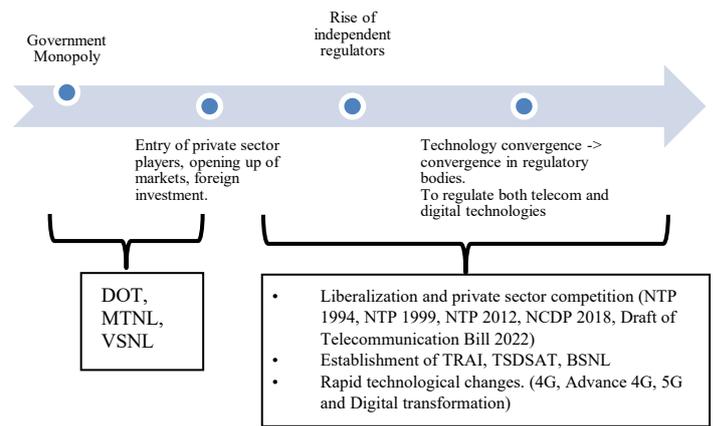


Fig.6. Indian (mobile) Telecommunication Industry Regimes within the Political scenario

Nevertheless, as technology was upgrading, so was the need for the MTS sector in the form of a new ecosystem, policies, and standards. As a result, with a focus on reasonable and high-quality telecommunication services in distinct and rural areas, the NTP-2012 was introduced to make sure that India fulfills this function efficiently and transforms the socioeconomic environment through accelerated inclusive and equitable economic growth. TSDSI (The Telecommunications Standards Development Society, India), was created in 2014 as the National Telecom SDO, which brought the Indian telecom industry's operators, manufacturers, academic institutions, and R&D organizations together to implement the 2012 National Telecom Policy.

In addition, government initiatives such as Make in India in September 2014, and Digital India Campaign in 2015 have also impacted the sector growth and technological development. Therefore, realizing the significance of Industry 4.0, the government developed the NDCP (National Digital Communications Policy) 2018 to unleash the transformative potential of digital communications networks in order to realize the goals of digital empowerment and improved human well-being, concentrating on three areas: (1) Connect India, (2) Propel India, and (3) Secure India.

Furthermore, in 2021, the GoI launched Gati Shakti – National Master Plan for Multi-modal Connectivity, prefiguring a new chapter in governance based on six pillars viz. Comprehensiveness, Prioritization, Optimization, Synchronization, Analytical, and Dynamic. Furthermore, on 24th February 2021 PLI Scheme for Telecom and Networking products was initiated. To reinforce the DoT, Draft Telecom Bill 2022 addressed the industry's need to merge and revamp the existing legal framework governing the telecommunication sector. The succeeding efforts are being determined in next-generation communication technologies, containing 5G (5G Test bed project, 5G Hackathon Application Development), forthcoming 6G (6G Technology Innovation Group (TIG)), Quantum Communications, etc.

Lastly the most significant over the past two decades and beyond, the GoI has also concentrated on international relations through activities like bilateral cooperation, multilateral cooperation activities, conferences of International and intergovernmental organizations, promotion events, international exhibitions and capacity building programmes with ITU/APT and ITUT study group meetings, and discussions are held with visiting foreign dignitaries aside from visits. Additionally, the DoT International Cooperation Division promotes international cooperation, followed by the Telecom Equipment and Services Export Promotion Council (TEPC), the Telecommunications Standards Development Society of India (TSDSI), the management of the Telecom Centres of Excellence (TCOE India), by hosting Exhibitions/Conferences and seminars [35]- [39].

B. Economic

The telecom sector primarily drives the global economy. It significantly influences everything from innovation and investment to boosting global competitiveness and helping to create jobs. When creating new products and services, telecom companies consider their customers' financial situations. Similar circumstances apply in India, where subscribers and customers are the industry's lifeblood. As a result, economic forces at play dictate how many and how many customers choose from the available telecom operators.

Consumers now have a substantially broader range of options to choose from than they did before liberalization when they only had BSNL as an option. In fact, there has been a propensity for Indian consumers to overspend on consumer goods and services as their disposable incomes have increased, and the telecom sector is one of the main legatees of their generosity. Indian consumers are also increasingly spending on VAS, or value-added services, in addition to their basic mobile plans, which means they have the potential to boost revenues for the operators due to rising incomes and aspiration levels.

The telecommunications industry, particularly wireless communication, indirectly and directly impacts the nation's economic development. The rise in teledensity will directly impact employment and revenue. The telecom industry has undergone tremendous expansion, which should undoubtedly boost sales and help the nation's economy grow.

The TRAI has consistently provided the foundation for actions to promote the expansion of the telecom sector. India's becoming a major player in the global information society is attributable to TRAI's efforts to innovate in the cable, television, and telecommunications industries. Applications such as Aadhar, e-government, e-trade, e-health, and e-education have all been made feasible in significant part by TRAI.

Regarding funding, the MTS sector mostly received funding from the Indian government through budgetary allotments, which have been rising over time. However, the telecom sector's share of overall economic investment remained roughly constant at 2.81 percent until 1985. Following that, the planned percentage of investment for 1992–1997 increased dramatically to 5.8 percent. However, in the Tenth Five-Year Plan, the telecom sector's contribution was raised to 6.5%. The Eleventh Plan also envisions the ongoing development of a top-notch communications infrastructure with a focus on expanding access. Whereas the Telecom Finance Corporation was

suggested in the Twelfth Five-Year Plan to obtain funds to support the Telecom Sector's demands in the event of necessity.

Besides the government investment, one of the significant sources of the substantial financial investment required for teledensity growth has been Foreign Direct Investment (FDI), because FDI has been crucial in determining how the telecom industry has developed through time and in funding the country's construction of telecom infrastructure. Additionally, it has significant advantages by increasing productivity, bolstering infrastructure, boosting the domestic economy's competitiveness, and creating new job possibilities. Till 2000, 7.04 percent of Total FDI has been invested. After that, this improved; in 2020, that has increased to 8.89. percentage of that has been invested in the Indian telecom sector.

The other contribution in an economic context can be seen in telecom revenues comprising Gross Revenue and Adjusted Gross Revenue (AGR), ARPU per month, Spectrum Usage Charges, License fee, and Spectrum Auction related Proceed. In the current context, the telecom sector Gross revenue mounted at Rs. 76,408 crores (US\$ 9.3 billion) in the first quarter of FY23. [39] – [48].

C. Social

Technology development has always had a direct impact on society. A wired form of communication, Telephones were crucial for maintaining friendly relationships with family members. It opened the door for calling and speaking with anyone on the globe. Mobile phones were invented, and their portability, in particular, has elevated them to the status of bodily organs. A person's life now cannot be imagined without a mobile phone. Through numerous social media and instant messaging platforms, it has created a new way of communicating with people throughout the globe.

Today's communication is not just voice but also audio and visual, which strengthens bonds between people. COVID-19 connections have been fostered during the epidemic thanks to the telecom industry's use of the mobile and internet phones. Due to their increased global exposure, mobile phones have given the younger generation an obsession that may be both a menace and a benefit. Information that was formerly thought to be private is now being made available to the public. Today, the connection is a new culture, changing the fundamental notion.

Previously, using a mobile phone in a place of business or church was frowned upon, but this is no longer the case. The idea of mobile phones, where phone numbers are more important than actual people, is what is influencing our culture today. The telecom industry has added a new dimension to entertainment and commerce through online mode. Significantly impacted are the social-physical contacts that aided in getting to know people. Cell phones have significantly impacted social interaction, primarily text messages and cell calls, offering the social environment a fresh perspective. Today, social connections occur online with people worldwide, bridging the gaps in time and geography. Today's youth are more worried about their virtual buddies than the members of their actual family [49] - [52].

D. Technological

Technology is all around us today. It is used for communication, education, and entertainment. Without

question, the emergence of new technologies has had a huge impact on the communications industry. While the prices of cell phones and internet subscriptions have drastically decreased in recent years, the quality and range of products available have significantly increased.

Technology and the telecom industry are intertwined since both are vital to the progression of the telecom industry. Today, the sector is viewed as highly technical and constantly striving to offer high-quality communication. India now has a 60.63% smartphone penetration rate as of 2021. The penetration rate is increasing exponentially, and India is predicted to have 95% of the world's smartphones by 2040.

With approximately 99% of mobile users switching to online mode, India has fully embraced the 4G. The 4G service spearheaded the nation's digital revolution. The country will undoubtedly transition to an entirely technologically driven society with applications like artificial intelligence, robotics, quantum computing, virtual reality, etc., dominating the market with the introduction of 5G services. These technological advancements will directly impact the telecom industry, which will be crucial to making it a reality.

According to Govindarajan (2016), the three main technological advancements that have occurred within the MTS are advancements in computerization, digitalization, and miniaturization; advancements in Internet, mobile communications, and packet-based NGN (Next Generation Networks) have led to the convergence of services; and advancements in ICT as a general technology to redesign and rationalize production, transaction, and administration, processes and to form new products and processes to build the information society.

As was previously mentioned, mobile telecom began with 1G globally, but in India, it began with 2G right away, which is to say, from 2G to 5G generation waves. The introduction of 2G services in India can be seen as a period of radical innovation, followed by a wave of incremental innovation (see Figure 7 and Table I) [54].

Due to high logistics costs, unstable power supplies, and intense competition from low-cost Chinese equipment, the manufacture of telecom equipment in India is also being focused. Even the application of the telecom sector based on mobile telephony, such as biometrics in IoT, smart homes, smart cities, and mobile phones, has also been utilized as Connectivity is a critical factor in the growth. This demonstrates that technological developments or elements will be crucial in telecommunications.

The profitability of the telecom industry is strongly correlated with technological improvements. For example, E-governance promises to provide citizens with simple access to government services via broadband connections at a lower cost and faster turnaround time. A person's daily life relies heavily on the internet or broadband services due to the shift towards digitalization. The telecom industry is a significant factor in India's to digital economy transition and makes significant contributions to e-Government in sectors as important as health, education, transportation, skill development, agriculture, employment, and banking. As a result, there is more accountability on the side of the government, and citizen-government relations are improved [53] - [57].

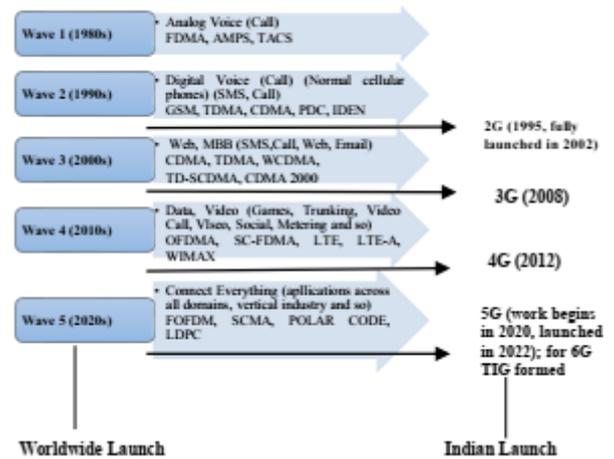


Fig.7. The Evolution Waves of Mobile telecommunication (worldwide and in India)

TABLE I
THE INNOVATION PATTERN AND ECOSYSTEM FROM 2G TO 5G MOBILE TECHNOLOGIES

	Key network Performance and Features	Network Radical Innovation	Network Incremental innovation	Ecosystem Innovation
2G	Digital Voice Data Rate: 10 Kbps to 380Kbps	TDMA/CDMA, GSM, CDMA one Standard & Product	2.5G: GPRS, HSCSD, WAP, 2.75G: EDGE, Bluetooth	Feature phone, SMS, WAP
3G	MBB Data Rate: DL 3.6 Mbps, UL 400 Kbps	CDMA, TDMA, WCDMA, CDMA2000, TD-CDMA standard & products	HSPA+, WiMAX 2	Smartphone, GPS, mobile modem, mobile Internet, QQ
4G	Better and Faster MBB, Data Rate: DL 100-150 Mbps, UL 40-50 Mbps, Delay: 20-40 ms	OFDM, LTE-FDD/TDD, WiMAX standard & products, All IP, SDR, MIMO, Smart Antenna Array	LTE-A (Data Rate: Down 1 Gbps, Up 500 Mbps), MIMO, VoLTE, IPV6 support	Smart Phone, Mobile APP, Video, WeChat, NB-IoT
5G	Connect Everything, Data Rate: DL 20 Gbps, UL 10 Gbps, Delay: 1ms, Connection: 1 M/Km ²	FOFDM, SCMA, LDPC and Polar Code MIMO, Millimeter wave, SDN/NFV, MEC	Evolution with AI, Cloud Native technology	eMBB: VR/AR, 8K Video, uRLLC, mMTC

E. Legal

The Indian Wireless Telegraphy Act, 1933 and the Indian Telegraph Act 1885 were the legal cornerstones for the central government's monopoly on telecommunications up until 1985. Posts and telecommunications were integrated under these regulations and controlled by the Ministry of Communications' P&T department. Protests against poor service by customers, legislators, businessmen, and industrialists occurred simultaneously as national and international demand for liberalization in the late 1970s and early 1980s. As a result, a legislative committee that made various recommendations for structural and service reforms was established in 1981.

Two purported public sector undertakings (PSUs), VSNL and MTNL, were founded in 1985 as a distinct DoT under the Ministry of Communications to develop, manage, and extend significant portions of the Indian telecommunications sector. The NTP 1994 laid the foundation for liberalizing the telecom industry. With the entrance of new players and to control telecommunication services and support the legal framework for communications in India, for example, DoT, TRAI, TDSAT,

WPC, C-DoT, TEC, Telecom Commission. Followed by TSDSI, the Indian SDO, to achieve national goals for digital communication standards; will work with other groups to play a crucial role both domestically and internationally. It increases industrial, start-up, and research community skills and actions for pre-standardization and standardization in the domestic market. Additionally, several organizations provide the legal framework required to govern the industry (see Figure 8).

costs can be reduced by 15–35%), and standardization of hardware, testing, and certification.

Then, in January 2017, a document titled Consultation Paper on Approach Towards Sustainable Telecommunication outlined the significance of energy efficiency in contemporary telecom networks and offered suggestions for improving the network's performance based on energy demands. The approaches that might be used to determine the network's carbon footprint and ways to meet renewable energy targets in this sector were thoroughly reviewed in this article.

All telecom equipment, software, and services should be energy-efficient, performance-tested, and "Green Passport [GP]" certified, according to the TRAI report. To standardize test procedures and certify telecom equipment for Green Passport based on ECR (Energy Consumption Rating), the TEC (Telecommunication Engineering Centre) under the DoT, GoI completed the first phase of setting up the Green Passport Lab in 2021.

The Indian telecom sector has also launched several sustainability efforts to advance ESG (Environmental, Social, and Governance) aims and create a more sustainable environment. For instance, Airtel pledged to cut its absolute Scope 1 and 2 GHG emissions by 50.2% until FY2031 (with FY2021 as the base year) and targets to achieve net zero emissions by 2050 [60] – [66].

V. CONCLUSION

As a result of the GoI's actions in liberalization, privatization, and demonopolization, the (mobile) telecom sector has experienced substantial growth and development throughout the years. The sector was deregulated as a result of the Indian economy being opened up, which made its many rivals more competitive. Reduced pricing, roaming plans, data rates, mobile phones for various market groups, loyalty programmes, and celebrity endorsements result from increased competition.

To illustrate the sector's development over the past two decades and beyond, the article begins with an outline of the Indian (mobile) telecom sector. It then analyses the industry's economic, political, social, legal, technological, and environmental aspects using the PESTLE approach. Due to economic and legal uncertainty, there are fluctuations in the quantity of FDI in the telecommunications industry. However, the government has set goals to increase the telecom sector's GDP to strengthen the Indian economy.

According to the study's findings, the telecom industry's revenue is increasing because of the increased number of subscribers. Examples of social aspects with a wide range of potential include digital education, telemedicine, e-commerce, e-education, smart cities, mobile banking, and mobile health. Technology's position in India has evolved substantially, and businesses and operators in those industries need to concentrate on that instead of only focusing on cities. Businesses in rural locations are missing out on opportunities.

With the introduction of new technologies, the sector is expected to become even more aggressive and competitive in the following years. It will be interesting to see how the major players adjust to these environmental changes. In that situation, the study might help comprehend the industry and aid in the creation of relevant policies.

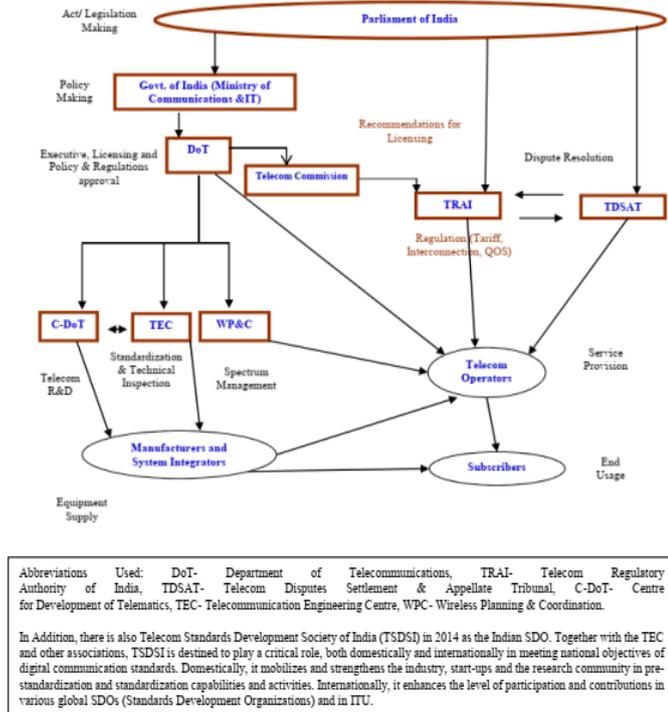


Fig.8. Indian Telecom Regulatory Framework

Indian telecom markets in the world continue to be the fastest-growing. Reforms introduced by successive GoI over the last decade have dramatically changed the telecommunications sector nature in the country as NTP 1999, NTP 2012, NDCP 2018, Indian Telegraph Right of Way (Amendment) Rules, 2022; PLI Scheme for Telecom and Networking products, Champion Service Sector Scheme (CSSS), Digital Intelligence Unit (DIU); Public procurement Preference to Make in India (PPP-MII), Sanchar Kaushal Initiatives, National Frequency Allocation Plan 2022 and so [58], [59].

F. Environmental

Around 1% of the nation's overall carbon dioxide (CO₂) emissions, or more than the benchmark of 0.7%, are attributed to the Indian telecom sector. Because emerging technologies like 5G, robotics, the IoT, AI, and others will significantly increase energy consumption, it is imperative to formulate and adhere to alternative energy solutions.

The primary impetus for telecom operators initiating sustainability plans and activities is TRAI. The Consultation Paper on Green Telecommunication, backin 2011 published by TRAI focusing on energy-efficient hardware and cutting-edge technologies adoption, the renewable energy sources use (such as solar, wind, ocean/tidal, and biomass), infrastructure sharing, improved grid supply, better network planning (so that energy

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