

**SELECT STUDY OF CONSUMER PERCEPTION
ON THE EFFECT OF EMF DUE TO
SMARTPHONE USAGE**

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by

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CERTIFICATE

The thesis entitled “Select Study of Consumer Perception on the Effect of EMF due to Smartphone Usage” being submitted by Ms. Monika Sharma to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy (Ph.D.) is a record of bonafide research work carried out by her. She has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has attained the standard required for a Ph.D. degree from the Indian Institute of Technology Delhi. The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Telecom sector in India has gone through significant changes in recent years. More than just a voice communication medium, it is now contributing a lot towards economic growth and financial inclusion of poorest of the poor. Smartphones have played an essential role in empowering people. There is also substantial change towards using telecommunication to play a significant role in value-added services, such as online banking, m-health, m-commerce, m-governance, m-education, etc. Many business decisions are now facilitated through telecom infrastructure, and therefore it is contributing towards the overall GDP of a nation. However, the mobile teledensity is still far from satisfactory especially in rural and semi-urban areas, thus having a high growth potential both in quantitative and qualitative terms. India is currently the second-largest telecommunication market (1209.96 million subscribers) and has the third highest number of internet users (367.48 million subscriptions) in the world. This has resulted in several new business opportunities within and outside the Indian telecommunication ecosystem. The Indian telecom service providers are, on the one hand, looking for additional revenue streams by offering into innovative markets and on the other hand trying to manage their operational cost, the rapidity of growth and the capability to meet market challenges.

An essential aspect of telecom sector is strong interdependence of different subsystems like mobile devices manufacturing, service delivery, tower technology, application development, etc. on one another. With fast technological convergence, the mobile devices are becoming smarter day by day and smartphone is becoming the ubiquitous equipment for both personal and business levels. Health issues related to the electromagnetic radiations of the mobile phone are one of the significant problems in the developing countries, and there are many drivers like social media, which are

shaping public perception of the Electromagnetic field (EMF) issue in developing countries like India. Electromagnetic emission of the mobile phone is one of the significant problems of the developing nations. There are many drivers, which are shaping public perception of the EMF issue in the developing country like India.

Everyone in the ecosphere is nowadays unprotected to a complex combination of EMF frequencies. Such types of issues have produced a negative perception in society related to adverse outcomes, no matter whether the risk is real or perceived.

In the first phase of the research study, the experts' opinion has been taken, and variables have been identified. These variables impact the consumer perception towards the EMF radiations from Smartphone. With the help of Total Interpretive Structural Modelling (TISM), the hierarchical structural model has been developed. The variables are then categorized into four clusters with the support of Matrice d'Impacts Croises-Multiplication Appliquee (MICMAC) analysis.

In the Second phase of the research study, the experts' opinion has been taken, and variables have been identified that impact the consumer perception towards the EMF radiations from a smartphone. Fuzzy Set Theory and Evidential Reasoning Algorithm have been used to determine the priorities of the variables after that sensitivity analysis has been performed. Ranking of different enablers has been evolved. A sensitivity analysis has been conducted to find out which variable is sensitive to the various aspects. It is useful in identifying the relevant variables which are the most influencing variables for the customers.

In the third phase of the research study, a questionnaire-based survey has been performed to capture the consumer perception through the study towards the EMF radiations from smartphone. With the help of statistical analysis, hypothesis testing has

been conducted. Research hypotheses have been formulated to test the linkages among the mobile radiations factors. The proposed linkages among the constructs and variables are operationally hypothesized and empirically tested.

The last phase of the study involves the case study approach to understand the scientific evidence and ground reality of the smartphone and tower radiations. In this study, SAP-LAP (Situation Actor Process - Learning Action Performance) Hills framework has been used to describe learning from the relationships between the enablers. This was further enlarged with literature review and expert opinion to reach the set of the enabling variables. Around these variables, a semi-structured interview was conducted, and responses were collected from a different segment of the telecom experts and users. The study provides essential implication for practitioners and academician. Limitations of study and scope of future research work were also documented. The thesis has also revealed some relevant facts for policymakers. Supportive Government policy, entrepreneur growth and global competitiveness have been the strategic enablers for the telecom industry, and low R&D investment has been the most significant barrier to the growth of the telecom ecosystem. This study provides the foundation for one of the least studied areas in smartphone.

सार

हाल के वर्षों में भारत में दूरसंचार क्षेत्र में महत्वपूर्ण बदलाव हुए हैं। सिर्फ एक आवाज़ संचार माध्यम से अधिक, यह अब गरीबों के आर्थिक विकास और वित्तीय समावेश के लिए बहुत योगदान दे रहा है। स्मार्टफोन ने लोगों को सशक्त बनाने में एक महत्वपूर्ण भूमिका निभाई है। ऑनलाइन बैंकिंग, एम-हेल्थ, एम-कॉमर्स, एम-गवर्नेंस, एम-एजुकेशन इत्यादि जैसे मूल्य वर्धित सेवाओं में महत्वपूर्ण भूमिका निभाने के लिए दूरसंचार का उपयोग करने में भी काफी बदलाव आया है। कई व्यावसायिक निर्णय अब दूरसंचार के माध्यम से सुविधाजनक हैं बुनियादी ढांचा, और इसलिए यह एक राष्ट्र के सकल घरेलू उत्पाद की ओर योगदान कर रहा है। हालांकि, मोबाइल उपयोग का घनत्व अभी भी ग्रामीण और अर्ध शहरी क्षेत्रों में संतोषजनक से बहुत दूर है, इस प्रकार मात्रात्मक और गुणात्मक दोनों शर्तों में उच्च वृद्धि क्षमता है। भारत वर्तमान में दूसरा सबसे बड़ा दूरसंचार बाजार (120 9.9 6 मिलियन ग्राहक) है और दुनिया में तीसरे सबसे ज्यादा इंटरनेट उपयोगकर्ता (367.48 मिलियन सब्सक्रिप्शन) हैं। इसके परिणामस्वरूप भारतीय दूरसंचार पारिस्थितिक तंत्र के भीतर और बाहर कई नए व्यावसायिक अवसर सामने आए हैं। भारतीय दूरसंचार सेवा प्रदाता, एक तरफ, अभिनव बाजारों में पेशकश करके अतिरिक्त राजस्व धाराओं की तलाश कर रहे हैं और दूसरी ओर अपनी परिचालन लागत, विकास की तेजी और बाजार चुनौतियों को पूरा करने की क्षमता का प्रबंधन करने की कोशिश कर रहे हैं।

दूरसंचार क्षेत्र का एक आवश्यक पहलू मोबाइल उपकरणों के विनिर्माण, सेवा वितरण, टावर प्रौद्योगिकी, अनुप्रयोग विकास इत्यादि जैसे विभिन्न उपप्रणालीओं पर एक दूसरे पर मजबूत परस्पर निर्भरता है। तेजी से तकनीकी अभिसरण के साथ, मोबाइल डिवाइस आज के समय में बेहतर बन रहे हैं और स्मार्टफोन व्यक्तिगत और व्यावसायिक दोनों स्तरों के लिए सर्वव्यापी उपकरण बन रहा है। मोबाइल फोन के विद्युत चुम्बकीय विकिरण से संबंधित स्वास्थ्य मुद्दे विकासशील देशों

में महत्वपूर्ण समस्याओं में से एक हैं, और सोशल मीडिया जैसे कई ड्राइवर हैं, जो भारत जैसे विकासशील देशों में विद्युत चुम्बकीय क्षेत्र (ईएमएफ) मुद्दे की सार्वजनिक धारणा को आकार दे रहे हैं। मोबाइल फोन का विद्युत चुम्बकीय उत्सर्जन विकासशील देशों की महत्वपूर्ण समस्याओं में से एक है। ऐसे कई ड्राइवर हैं, जो भारत जैसे विकासशील देश में ईएमएफ मुद्दे की सार्वजनिक धारणा को आकार दे रहे हैं।

पारिस्थितिक क्षेत्र में हर कोई ईएमएफ आवृत्तियों के जटिल संयोजन के लिए आजकल असुरक्षित है। इस तरह के मुद्दों ने प्रतिकूल परिणामों से संबंधित समाज में नकारात्मक धारणा पैदा की है, इससे कोई फर्क नहीं पड़ता कि जोखिम वास्तविक है या नहीं। शोध अध्ययन के पहले चरण में, विशेषज्ञों की राय ली गई है, और चर की पहचान की गई है। ये चर स्मार्टफोन से ईएमएफ विकिरण की ओर उपभोक्ता धारणा को प्रभावित करते हैं। टोटल इंटरप्रेटिव स्ट्रक्चरल मॉडलिंग (टीआईएसएम) की सहायता से, पदानुक्रमित संरचनात्मक मॉडल विकसित किया गया है। चर को फिर मैट्रिस डी इंपैक्ट्स क्रोसिस-गुणात्मक उपकरण (एमआईसीएमएसी) विश्लेषण के समर्थन के साथ चार क्लस्टर में वर्गीकृत किया जाता है।

शोध अध्ययन के दूसरे चरण में, विशेषज्ञों की राय ली गई है, और चर की पहचान की गई है जो स्मार्टफोन से ईएमएफ विकिरण की ओर उपभोक्ता धारणा को प्रभावित करती है। उस संवेदनशीलता विश्लेषण के बाद फेरा एल्गोरिदम का उपयोग चर के प्राथमिकताओं को निर्धारित करने के लिए किया गया है। विभिन्न चरों की रैंकिंग विकसित किया गया है। यह पता लगाने के लिए कि कौन सा चर विभिन्न पहलुओं के प्रति संवेदनशील है, एक संवेदनशीलता विश्लेषण आयोजित किया गया है। यह प्रासंगिक चर की पहचान करने में उपयोगी है जो ग्राहकों के लिए सबसे प्रभावशाली चर हैं। शोध अध्ययन के तीसरे चरण में, स्मार्टफोन से ईएमएफ विकिरण की ओर अध्ययन के माध्यम से उपभोक्ता धारणा को पकड़ने के लिए एक प्रभावशाली आधारित

सर्वेक्षण किया गया है। सांख्यिकीय विश्लेषण की सहायता से, परिकल्पना परीक्षण आयोजित किया गया है। मोबाइल विकिरण कारकों के बीच संबंधों का परीक्षण करने के लिए अनुसंधान परिकल्पना तैयार की गई है। संरचनाओं और चर के बीच प्रस्तावित संबंधों को परिचालन रूप से परिकल्पना और अनुभवी परीक्षण किया जाता है।

अध्ययन के अंतिम चरण में वैज्ञानिक साक्ष्य और स्मार्टफोन और टावर विकिरण की ग्राउंड रियलिटी को समझने के लिए केस स्टडी दृष्टिकोण शामिल है। इस अध्ययन में, एसएपी-एलएपी (स्थिति अभिनेता प्रक्रिया - लर्निंग एक्शन परफॉर्मेंस) हिल्स फ्रेमवर्क का उपयोग एनबेलर्स के बीच संबंधों से सीखने के वर्णन के लिए किया गया है। सक्षम चर के सेट तक पहुंचने के लिए इसे साहित्य समीक्षा और विशेषज्ञ राय के साथ आगे बढ़ाया गया था। इन चर के आसपास, एक अर्ध-संरचित साक्षात्कार आयोजित किया गया था, और दूरसंचार विशेषज्ञों और उपयोगकर्ताओं के एक अलग सेगमेंट से प्रतिक्रियाएं एकत्र की गई थीं।

अध्ययन प्रैक्टिसनर्स और शिक्षाविदों के लिए आवश्यक निहितार्थ प्रदान करता है। भविष्य के शोध कार्यों के अध्ययन और दायरे की सीमाओं को भी दस्तावेज किया गया था। थीसिस ने नीति निर्माताओं के लिए कुछ प्रासंगिक तथ्यों का भी खुलासा किया है। सहायक सरकारी नीति, उद्यमी विकास और वैश्विक प्रतिस्पर्धा दूरसंचार उद्योग के लिए रणनीतिक समर्थक रही है, और कम आर एंड डी निवेश दूरसंचार पारिस्थितिकी तंत्र के विकास में सबसे महत्वपूर्ण बाधा रहा है। यह अध्ययन स्मार्टफोन में कम से कम अध्ययन क्षेत्रों में से एक के लिए आधार प्रदान करता है।

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ABBREVIATIONS

| | |
|---------|---|
| G | Generation |
| BSNL | Bharat Sanchar Nigam Limited |
| CDMA | Code Division Multiple Access |
| COAI | Cellular Operators Association of India |
| DOT | Department of Telecommunications |
| FDD | Frequency Division Duplex |
| FDI | Foreign Direct Investment |
| GSM | Global System of Mobile Communication |
| ICNIRP | International Commission on Non-Ionizing Radiation Protection |
| IT | Information Technology |
| MICMAC | Matrice d'Impacts Croises-Multiplication Appliquee |
| RCOMM | Reliance Communications |
| R&D | Research & Development |
| SAR | Specific Absorption Rate |
| SAP-LAP | Situation – Actor – Process, Learning – Action – Performance |
| TISM | Total Interpretive Structural Modelling |
| TRAI | Telecom Regulatory Authority of India |