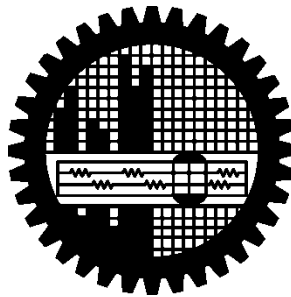


Strategy Formulation for Successful Adoption of 4G Technology by Telecommunication Operators in Bangladesh

by

Fahim Mahmud

A thesis submitted to the Institute of Appropriate Technology (IAT), Bangladesh University of Engineering & Technology (BUET) in partial fulfillment of the requirement for the degree of Master of Science in Management of Technology (MOT).



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CERTIFICATE OF APPROVAL

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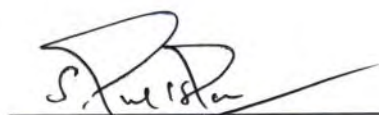
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ABSTRACT

Fourth generation of wireless technology i.e. 4G technology is the latest wireless network technology. With a lot of interactive features and better performance, 4G seems to be more promising than existing 2G and 3G technologies. Upon analyzing current deployment of 4G Technology, it is found that commercial usage of this technology is growing very fast around the world. This is evident that Bangladesh needs to join 4G Technology run to cope up with the world-wide technological advancement spree.

Launching of 4G technology will create a major impact in the market and economy of Bangladesh. Proper planning is required for management of this new technology while launching. For all operators, a concrete adoption strategy is very important. This study aims to identify the critical factors, formulating a strategic plan and development of a model for successful adoption of 4G technology by telecommunication operators in Bangladesh. In addition, this study also analyzes the present scenario of existing telecommunication technologies in Bangladesh and appropriateness of introducing 4G technology here.

Study is conducted by the milestones of research model development, data collection, analysis and decision making. Primary data is collected from a survey conducted among 40 experts selected from the telecommunication domain of Bangladesh. Closed-ended and open-ended questions are used. Secondary data are collected from papers, journals, related studies, documents, books, internet, newspaper review etc. For statistical analysis and decision making, Analytic Hierarchy Process (AHP) is used. AHP analysis tools and Microsoft Spreadsheet are used for calculation.

In this research it is found that, telecom consumers are not completely satisfied with the existing 2G and 3G technology available in Bangladesh. Summary of experts' opinion also indicates that customers will appreciate introduction of 4G technology and Bangladesh need to launch 4G technology within in less than 4 years. Final outcome of this research work depicts that Technology is the most critical factor for successful adoption of 4G technology by telecom operators in Bangladesh. Other critical sub-factors are identified as Network

coverage and quality, Technological up-gradation, Product, packages and pricing, Advertising and branding. Though operators in Bangladesh are still focused on Voice business but according to the research outcome, core strategy for operators to successfully adopt 4G technology is formulated as “focus in Data service”. Research outcome indicates that operators must ensure 4G network coverage throughout the country maintaining proper quality as quickly as possible upon launching. Technological up-gradation must be done by operators with proper care. Infrastructure development for 4G technology and up-gradation of existing 2G and 3G equipment to 4G enabled equipment should be completed quickly and smoothly. Pricing of 4G technology needs to be more attractive than existing 2G and 3G pricing. A balanced pricing should be set considering customers’ expectation and affordability and operators’ return of investment and profitability. Operators must inform their customers about the benefits and new features of this new technology through proper advertising. Considering the competition, each individual operator needs to become a true 4G-branded operator through appropriate branding. Operators also need to ensure that 4G technology can be used with as less negative impact as possible. Telecom sites must be installed in planned manner. Operators need to consider impact of radiation generated from telecom equipment while adopting 4G technology.

Based on the results obtained through the research, a strategic plan is formulated for successful adoption of 4G technology by telecom operators in Bangladesh. A model for this adoption is also developed, named as “4G Technology Adoption Model”. Some suggestions are also made to the government. The thesis outcome is also aligned with national policies and vision.

Finally it can be said that introducing 4G technology will be a major step towards “Digital Bangladesh”, which is a major goal of “Vision 2021” articulated by Government of Bangladesh. Not only operators but all concerned organizations and authorities in telecommunication domain of Bangladesh may review this thesis paper for successful adoption of 4G technology.

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LIST OF ABBREVIATIONS

1G	First Generation
2G	Second Generation
3G	Third Generation
3GPP	3rd Generation Partner-ship Project
4G	Fourth Generation
AHP	Analytic Hierarchy Process or Analytical Hierarchy Process
AMPS	Advanced Mobile Phone System
AMTOB	Association of Mobile Telecom Operators of Bangladesh
ARPU	Average Revenue Per User
BDT	Bangladeshi Taka
BTRC	Bangladesh Telecommunication Regulatory Commission
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CI	Consistency Index
CR	Consistency Ratio
EDGE	Enhanced Data Rate for GSM Evolution
ETACS	European Total Access Communication systems
EUL	Enhanced Uplink
FDI	Foreign Direct Investment
FDMA	Frequency Division Multiple Access
FDMA	Frequency Division Multiple Access
Gbps	Gigabits per second
GDP	Gross Domestic Production
GIS	Geographic Information System or Geographical Information System
GP	Grameenphone
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Systems for Mobile Communications
HSPA	High-Speed Packet Access
HSPA+	Evolved HSPA
HSUPA	High-Speed Uplink Packet Access

ICNIRP	The International Commission on Non-Ionizing Radiation Protection
IMSI	International Mobile Subscriber Identity
ICT	Information and Communication Technology
IT	Information Technology
IP	Internet Protocol
ITU	International Telecommunication Union
Kbps	Kilo-bits per second
KHz	Kilo-Hertz
LSP	Local Service Providers
LTE	Long Term Evolution
Mbps	Megabits per second
MHz	Mega-Hertz
MIN	Mobile Identification Number
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
NFAP	National Frequency Allocation Plan
NTP	National Telecommunication Policy
NTT	Nippon Telegraph and Telephone
RUIM	Removable User Identity Module
SD	Supplementary Duty
SIM	Subscriber Identity Module or Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access
UMTS	Universal Mobile Telecommunications System
USA	United States of America
USD	United States Dollar
VAS	Value-added services
VAT	Value Added Tax
W-CDMA	Wideband Code-Division Multiple Access

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

3G, third generation of mobile communication technology, has spread around the world through bringing various applications to mobile phones [1]. Bangladesh also started its journey of 3G on 14th October, 2012 by government-owned telecommunication operator Teletalk [2]. In September, 2013 four more operators were awarded 3G spectrum (Grameenphone, Airtel, Banglalink and Robi) along with Teletalk [2]. These 5 operators are now increasing their 3G network. A successor to 3G standards, 4G technology is the fourth generation of mobile communication standard, which promises higher speed and better performance [3].

Telecommunication industry of Bangladesh is rapidly moving towards a crucial point with the introduction of 3G technology. Arrival of 4G technology will fasten this rapid movement. But in most countries, usage of 3G remains far below the expectation of operators [4]. With a lot of interactive features and better performance, 4G seems to be more promising [5]. As 4G is a new technology for the country, high risk is associated considering huge knowledge gap. Market situation, feasibility study i.e. appropriateness of this new technology, customer analysis, risk assessment, campaign, resource, infrastructure, pricing, socio-economic impact etc. need to be considered. Consumer behavior, needs, response, usage pattern, lifestyle etc. need to be analyzed deeply. Telecommunication operators in Bangladesh should carefully and timely develop their strategies to avoid delay or difficulties while introducing 4G technology [6].

Launching of 4G technology will create a major impact in the market and economy of Bangladesh. Successful adoption of 4G technology is very crucial for operators in Bangladesh. Proper planning is required for management of this new technology while launching. For all operators in Bangladesh, concrete strategy and appropriate model are very important for successful adoption of 4G technology.

1.2 Objectives

The objectives of this study are focused on the following points:

- i. To review the present scenario of the already adopted mobile communication technologies.
- ii. To examine the appropriateness pertaining to the introduction of 4G technology in Bangladesh in near future.
- iii. To identify the risks, barriers, difficulties and critical factors for telecommunication operators in Bangladesh to implement and adopt 4G technology.
- iv. To formulate the strategy and steps of adoption of 4G technology by telecommunication operators in Bangladesh.
- v. To develop a 4G Technology adoption model for telecommunication operators in Bangladesh.

The expected outcomes of this study are identification of critical factors, formulation of a strategic plan and development of an adoption model to successfully adopt 4G technology by telecommunication operators in Bangladesh.

1.3 Outline of Methodology

- (1) This study is conducted by the milestones of working strategy finalization i.e. research model development, literature review, preparation for survey, preparation and finalization of questionnaire, conduction of survey, analysis of collected data and decision making.

Also, activities of telecommunication operators are observed.

- (2) **Primary data collection:**

Primary data are collected from a survey using questionnaire which is performed by the ways of written survey.

(3) ***Population and area of population:***

Telecommunication operators, network equipment vendors, local service providers, universities and regulatory commission are the population of this study. Dhaka is the population area.

(4) ***Sampling technique and sample size:***

A standard sampling technique (Selective sampling method) is used based on selective criteria. Sample size is 40 that means survey is conducted to 40 experts.

(5) ***Questionnaire design:***

Closed-ended and open-ended questions are used. Questionnaire is prepared by following standard principles and basic tools.

(6) ***Secondary data collection:***

Secondary data are collected from papers, journals, related studies, documents, books, internet and newspaper review and other sources of information.

(7) ***Data compilation and accumulation:***

After data collection, primary and secondary data are compiled and accumulated for analysis.

(8) ***Statistical analysis and decision making:***

For decision making, analysis is conducted by using Analytic Hierarchy Process (AHP). AHP analysis tools and Microsoft Spreadsheet are used for calculation.

A summary of the overall methodology is represented in Figure 1:1 which illustrates the work-flow of this research work at a glance.

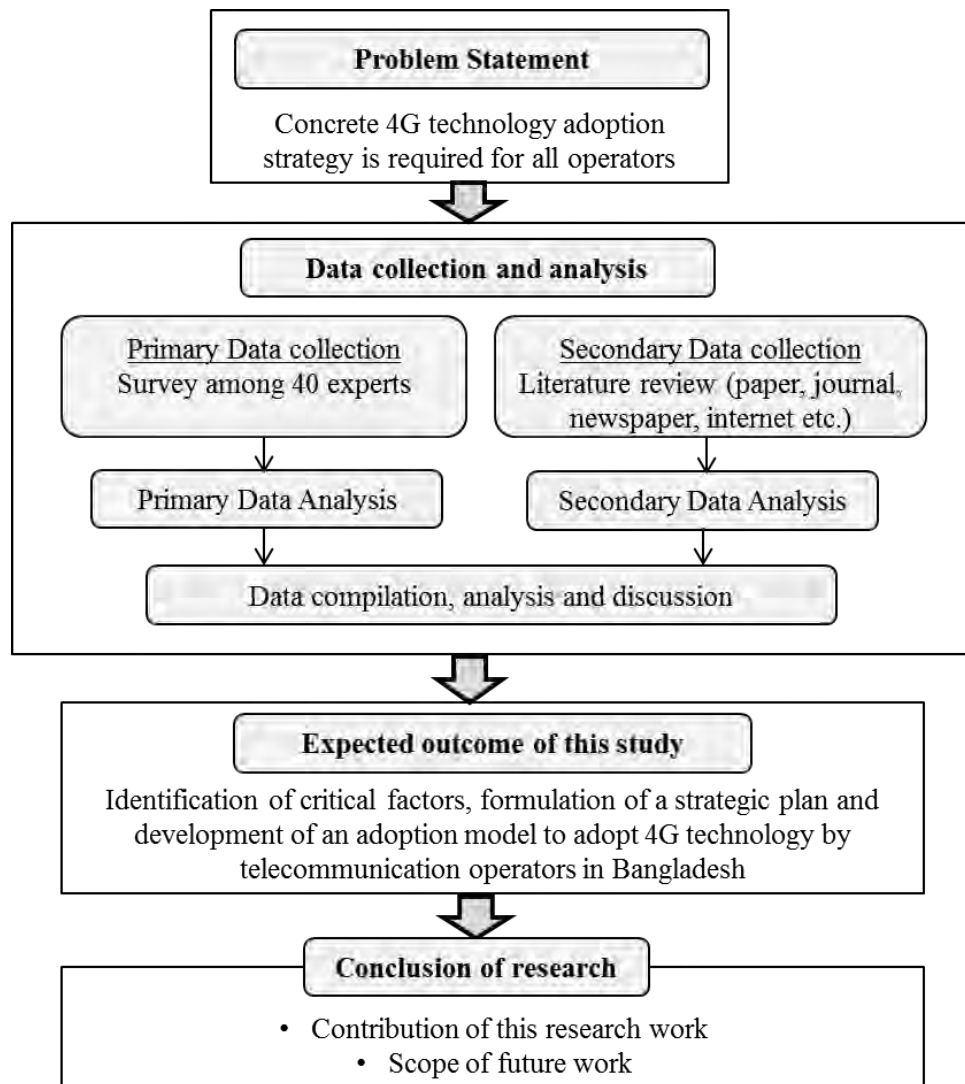


Figure 1:1 Summary of overall methodology

1.4 Organization of the Thesis

This thesis is organized in five chapters.

The first chapter contains the introduction to the thesis work. This chapter describes the problem statement, objective of the thesis work, outline of methodology and thesis organization.

Then in second chapter, a literature review is carried out to provide an overview on the Telecommunications technologies. Several technologies e.g. 1G, 2G, 3G and 4G are discussed. Furthermore, to highlight the present scenario of telecommunication technology in Bangladesh, governance of telecom sector, challenges in this sector, profile and market share of telecom operators of Bangladesh, spectrum allocation, contribution of telecommunication sector to the economy of Bangladesh etc. are also discussed in Chapter 2. In addition, a literature review is done on appropriateness of introducing 4G technology in Bangladesh.

In the third chapter, an overview on methodology and experimentation is provided. As a research tool of this study, Analytic Hierarchy Process (AHP) is introduced and discussed in details in this chapter. Research model is also discussed in details. Questionnaire for primary data collection is also developed. Finally, as a data analysis tool, AHP online application software (AHP-OS) is also introduced and discussed.

Fourth chapter contains detail analysis of the primary data collected through survey. Results and discussions are the major contents of this chapter. Identification of critical factors and formulation of a strategic plan to successfully adopt 4G technology by telecommunication operators in Bangladesh are presented. A model to adopt 4G technology by operators is also developed. Finally, the research outcome is integrated with the national policies and vision in this chapter.

Fifth and last chapter provides the conclusion to this research work. Contribution of this study and scope of future work are discussed in this chapter along with final conclusion of the thesis work.

Organization of these five chapters is illustrated in Figure 1:2.

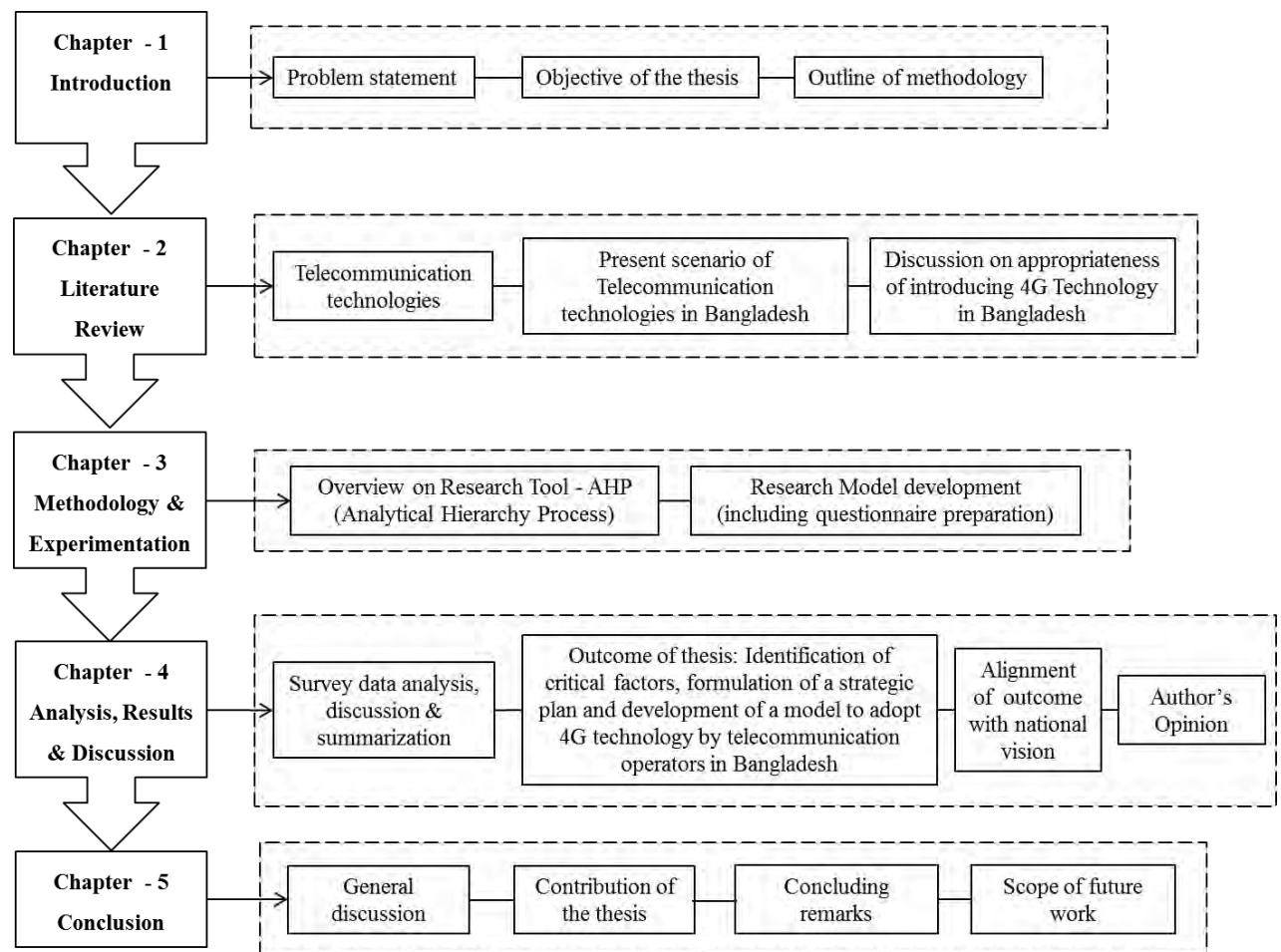


Figure 1:2 Organization of the thesis

1.5 Chapter Summary

Chapter 1 establishes a foundation path by which the researcher contributes to identify critical factors, formulate a strategic plan and develop a model to adopt 4G technology by telecommunication operators in Bangladesh.

Now that the overall structure of this thesis is set up, Chapter 2 presents a literature review on different telecommunication technologies and its present scenario in Bangladesh.

CHAPTER 2

LITERATURE REVIEW ON TELECOMMUNICATION TECHNOLOGY AND ITS PRESENT SCENARIO IN BANGLADESH

2.1 Introduction

In 21st century, mobile phones have rapidly become the most preferred means of personal communication and it has created the world's largest consumer electronics industry. With the advancement of technology the telecommunication industry has experienced significant growth and profits [7]. Mobile phones are now reasonably priced and widespread among all clusters of people. It has significant influence in extending and strengthening social networks and relations [8]. With the increasing popularity of different digital lifestyle devices such as smartphones, tabs, gadgets etc., and exponential growth of numerous apps, multimedia item, and cloud computing etc., telecommunication service providers are now forced to move towards more intelligent, advanced and highly capable wireless technologies while also providing sophisticated pricing schemes, including dynamic pricing [9].

This chapter reviews literature related to different telecommunication technologies which are relevant to this research. Also, literatures related to the present scenario of the already adopted mobile communication technologies in Bangladesh are also studied.

2.2 Telecommunication Technologies

A mobile phone (also known as a cell phone) is a device which makes and receives telephone calls over a radio network link. This is done by the mobile phone by connecting to a mobile network provided by a mobile phone operator, which allows access to the public telephone network [10]. Mobile network i.e. telecommunication network is a radio network spread over geographical areas which are called cells. Each cell is served by at

least one transceiver, known as a base transceiver station (BTS). In this network, each cell uses a different set of frequencies from neighboring cells. It is done to avoid interference and to provide guaranteed bandwidth within each cell.

In order to ensure maximum quality of service i.e. guaranteed bandwidth and no interferences; prior to implementation of new technology it is important to define set of rules and to impose standards. There are different kinds of standards and technologies related to each wireless communication generation. Approximately, every decade new infrastructure and wireless communication technology becomes available which involves a change in the nature of the service, technology compatibility, higher data rates, new frequency transmission bands, wider channel frequency bandwidth etc. [9].

2.2.1 First Generation – 1G Technology

First Generation of wireless mobile communications technology i.e. 1G Technology was introduced in Japan by NTT (Nippon Telegraph and Telephone) in 1979 [11]. It was based on analog signaling. These analog systems were designed based on circuit-switching technology and only for voice, not for data [7].

In USA, 1G operated on Advanced Mobile Phone System (AMPS) network. FDMA (Frequency Division Multiple Access) was used to divide the signals into number of channels. Channel bandwidth was 30 KHz. In the United States, transmissions from mobile station to base stations uses frequency between 824 MHz to 849 MHz, while base station transmits to mobile using frequencies between 869 MHz and 894 MHz. Data transmission rate of AMPS was 10 Kbps [11].

In Europe, in mid-1980, another system was developed named European Total Access Communication systems (ETACS). It was almost identical to AMPS except it used 25 KHz channels throughout Europe. Another difference between AMPS and ETACS was formation of different Mobile Identification Number or MIN, due to the requirement of accommodating different country codes throughout Europe and USA [11].

The capacity of 1G was very limited i.e. maximum 395 mobile users per tower. This network standard was permanently closed down in 1999 [9].

2.2.2 Second Generation - 2G Technology

Upon development of 1G, since 1985, International Telecommunication Union (ITU) has been developing different telecommunication standards [12].

2G Technology is the second generation of wireless mobile communications technology which is the successor of 1G. This is the first digital network which started replacing its predecessor analog system, 1G from 1991, i.e. ten years later to 1G [9].

During the 2G generation, telecommunications industry achieved tremendous growth both in terms of number of subscribers and also in terms of new types of value-added services (VAS) [7]. In 2G, features of 1G were improved and apart from that, 2G also offers many other important features like: Short Message Service (SMS), Multimedia Messaging Service (MMS), digital encryption for security, Internet packet data, caller ID and most importantly introduction of SIM card [9].

2G Technology was developed based on low-band digital data signaling. The most popular 2G technology is known as GSM i.e. Global Systems for Mobile Communications. GSM technology is a combination of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). Initially GSM systems used a 25 MHz frequency spectrum in the 900MHz band. FDMA was used to divide the allocated 25MHz of bandwidth into 124 carrier frequencies of 200 kHz each. Each 200 KHz frequency was then divided using a TDMA system into eight timeslots. Now-a-days, GSM systems operate in the 900 MHz and 1800 MHz bands throughout the world except the Americas where GSM is operated in the 1900 MHz band [7].

In the same time when GSM technology was developed in Europe, another technology called Code Division Multiple Access (CDMA) was developed in North America. CDMA

uses spread spectrum technology to break up speech into small, digitized segments and encodes them to identify each call [6]. Data rate of GSM is 9.6 Kbps [13].

Just like 1G, 2G technology also mostly based on circuit-switching technology. 2G has following transitional technologies: 2.5G, and 2.75G [9].

2.5G- GPRS (General Packet Radio Service) stands for second and a half generations cellular wireless technology developed in between 2G and 3G. Data rate of GPRS are ~115 Kbps. It can be used for services such as wireless application protocol access, multimedia messaging services and for accessing internet.

2.75- EDGE (Enhanced Data Rate for GSM Evolution) is another wireless technology developed in between 2G and 3G, invented by AT&T. It offers a data rate of 384 Kbps, theoretically up to 473.6 Kbps [13].

2.2.3 Third Generation - 3G Technology

In 1998, joint standardization project of the standardized bodies from Europe, China, Korea, USA and Japan was formed named 3GPP (the 3rd Generation Partnership Project). 3GPP developed the current 3G and 4G technology [12].

Third generation of wireless technology i.e. 3G technology is the convergence of different 2G systems into a single global system which includes both terrestrial and satellite components. One of the most important features of 3G technology is its capability to unite existing cellular standards, such as CDMA, GSM, and TDMA under one roof [7].

In 1998, the first pre-commercial 3G network was launched by NTT DoCoMo in Japan. The first commercial launch of 3G was also by NTT DoCoMo in Japan on 1st October 2001 [11]. 3G started its operations on 2100 MHz frequency band. This standard uses a new technology named Universal Mobile Telecommunications System (UMTS) as its basic network architecture. 3G technology combines features of the 2G network with some new technology and protocols 3G provides faster data speed compared to 2G. 3G has following transitional technologies: 3.5G, 3.75G and 3.9G [9].

In 3G/ UMTS system, multiple radio interfacing are offered, sharing the same infrastructure, as mentioned below:

- The most widespread radio interface is called W-CDMA, which stands for Wideband Code-Division Multiple Access. W-CDMA is a spread-spectrum modulation technique. Its data transmission rate varies between 384 Kbps (in case of wide area coverage) to 2 Mbps (in case of local coverage) [14].
- In W-CDMA 3GPP release 6, which was introduced in between 2000 ~ 2005, there was a new transmission channel in the uplink named Enhanced Uplink (EUL). EUL was sometimes also called as HSUPA (High-Speed Uplink Packet Access). HSPA (High-Speed Packet Access) is the combination of EUL and HSDPA. The data transmission rate for HSPA is in between 5.8 Mbps to 14 Mbps.
- In 2008, Evolved HSPA (or HSPA+) was released. HSPA+, can provide data transmission rate in between 56 Mbps (theoretically, 28 Mbps in existing services) and 22 Mbps [11].

3G technology supports higher data rates and intended for various applications in addition to voice services. Introduction of 3G gives subscribers a variety of new services such as Internet browsing, e-mail, instant messaging, video streaming and conferencing, digital television, different web-based applications location-based services etc. [15].

2.2.4 Fourth Generation - 4G Technology

Fourth generation of wireless technology i.e. 4G technology is the latest wireless network technology. 4G offers significantly faster data speed compared to 3G. 4G standard has been developed based on Long Term Evolution (LTE) which is a natural successor to 3G technologies as it is based on GSM, EDGE and UMTS / HSPA / HSPA+ network [9]. LTE was first released i.e. launched in Scandinavia in 2009 [11].

4G enhances maximum downlink speeds up to 100 Mbps and uplinks up to 60 Mbps. This is marketed as 4G LTE [9].

Each generation has its unique needs and aspirations. 4G technology will offer many improvements to the wireless service domain, including very high speed data rates, reduced network congestion, low latency, efficient spectrum usage and low-cost deployment. Implementation of 4G will bring the wireless network usage experience to totally new level with remarkable user applications like stylish graphical user interfaces, high-end gaming, high-definition video and high-performance imaging [16].

Based on above discussion, a summary of different telecommunication network generations and their data transfer speeds along with availability is presented in Table 2-1. A graphical representation of change in data transfer rate is provided in Figure 2:1 where it is clear how rapidly the data transfer rate has increased from technology to technology.

Table 2-1 Telecommunication technologies

Generation	Technology	Data Transmission rate	Availability
1G	AMPS	~ 10Kbps	1979-1999
	ETACS		Mid 1980s - 1999
2G	GSM	~ 9.6 Kbps	1990s
2.5G	GPRS	~ 115 Kbps	1990s
2.75G	EDGE	~ 384 Kbps	1990s
3G (UMTS)	W-CDMA	2 Mbps ~ 384 Kbps	2000s
	HSPA	14 Mbps ~ 5.8 Mbps	~ 2005
	HSPA+	28 Mbps ~ 22 Mbps	2008+
4G	LTE	100 Mbps ~ 60 Mbps	2009+

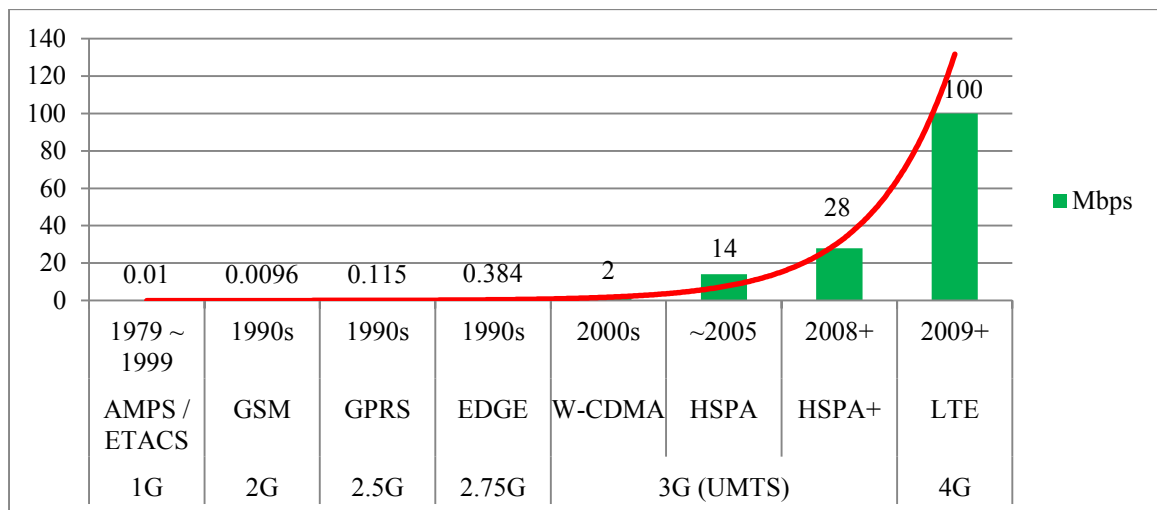


Figure 2:1 Data transfer rate of different telecommunication technologies

2.3 Present Scenario of the Existing Mobile Communication Technologies in Bangladesh

Telecommunication sector is one of the fastest developing service industries in Bangladesh. Bangladesh was the first South-Asian country to launch a live telecommunication network in 1993 [17]. Since then, telecommunication has been able to attract customers and currently Bangladesh has about 133.72 million mobile subscribers as of December 2015 [18]. For the last few years this sector is contributing to countries' economy through various services aside to telecom e.g. collaboration in online banking, money transfer, education, welfare services and so on. Besides these, this sector is now one of the major tax payers of Bangladesh Government [19]. This sector has also attracted highest amount of Foreign Direct Investment (FDI) in Bangladesh. This industry has also created numerous numbers of direct and indirect employments [17]. In following sub-sections, present scenario of existing telecommunication technologies in Bangladesh is discussed.

2.3.1 Current Governance Structure of Telecommunication Sector of Bangladesh

Telecommunication sector of Bangladesh is governed by concerned ministry, regulatory commission and association of operators. A brief overview is given below.

2.3.1.1 The Ministry

Post & Telecommunication Division under Ministry of Post, Telecommunications and Information Technology of Government of the People's Republic of Bangladesh is the concerned ministry for telecommunication sector of Bangladesh. This division is mainly concerned with policy making for providing telecommunication services in the country [20].

2.3.1.2 Regulatory commission

Bangladesh Telecommunication Regulatory Commission (BTRC) was formed on 31st January of 2002 under the Bangladesh Telecommunication Act, 2001 as an independent Regulatory Commission. BTRC was formed to provide reliable telecommunication services in the country [21].

According to the above mentioned act, BTRC is assigned with many responsibilities e.g., establishing, operating, regulating, maintaining telecommunication establishments and providing various telecom services in Bangladesh. Besides, fixing different charges are also done by BTRC subject to approval of government. BTRC ensures services for subscribers and also monitors socio-economic behavioral pattern of the telecom operators [21].

2.3.1.3 Telecom operators' association

Association of Mobile Telecom Operators of Bangladesh (AMTOB) is the national body representing all telecommunication operators in Bangladesh. It was established in 2001. AMTOB has appeared as the official voice for the Bangladesh telecom sector to interact with concern government bodies, regulators, financial institutes, civil society, technical

bodies, etc. It provides a platform for discussion and idea exchange among the stakeholders and industry players for the development of the telecom sector of Bangladesh [22].

All telecom operators of Bangladesh (i.e. Airtel, Banglalink, Citycell, Grameenphone, Robi, and Teletalk) are members of AMTOB [22].

2.3.2 Existing challenges for telecommunication operators in Bangladesh

There are some problems as well for the telecommunication sector of Bangladesh. They are briefly discussed below:

- a) **Tough Competition:** Too high competition in our country is one of the major problems of telecom sector. Before the year 2000, there were only three operators viz. City cell, Grameenphone and Robi (the then Aktel). They had the first-arrival advantages but when Banglalink, Teletalk, Airtel arrived in the competition then the market became more competitive and still high competition exists [23].
- b) **Lower consumer spending levels:** Bangladesh is still a developing nation and a lower-middle income country. Customer spending levels here is one of the lowest of the world. The ARPU (Average Revenue per User) is one of the lowest of the world. As of 2013, it is only 3.55 USD by subscriber [24]. Hence, it is a challenge for operators to operate a business like telecommunication service in Bangladesh with profit.
- c) **High Corporate Tax:** Telecommunication service providers of Bangladesh are paying very high corporate tax which is 40% for listed and 45% for non-listed operators. But this corporate tax rate for general listed companies is 27.5% and for non-listed is 37.5%. It is one of the biggest existing challenges for the operators [25].
- d) **SIM Tax:** In Bangladesh the telecom operators have to pay Tax for each SIM card sold. Initially it was Tk. 1200 when it was introduced in 2005-06. It has been gradually reduced. But even as of mid-2015, operators have to pay VAT of BDT

109.96 and supplementary duty (SD) of BDT 190.05 for each SIM/ RUIM supply. These VAT and SD are jointly called SIM Tax of BDT 300. Though tax is imposed on the subscribers but the operators give incentive to continue SIM selling at a convenient price to hold the market considering the competitiveness. Hence it is an additional burden for the operators [25].

- e) Import Tax and customs duty: Bangladesh is not technologically advanced to manufacture large scale telecommunication equipment. So phone operators import technologies and other equipment required to continue telecom services. Customs duty/ import tax etc. are very high for such cases that it is very tough for operators [23].
- f) Surcharge bill on mobile phone usage: Recently in November 2015, Parliament had passed “Development Surcharge and Levy (Impose and Collection)” bill to collect one percent surcharge on the use of mobile phone services [26]. This additional surcharge may impact mobile usage and operators’ profitability will be negatively affected.

2.3.3 Profile review of telecommunication operators in Bangladesh

A Telecommunication Operator also known as Mobile Network Operator (MNO) is a provider of wireless communications services such as mobile telephony and mobile Internet broadband. Typically, telecom operators owns or controls all the elements of the network that are necessary to sell and deliver services to an end-user including but not limited to; radio spectrum allocation, wireless and fixed network infrastructures, sales and marketing, billing, repair and maintenance of network, customer care etc. [9]. Usually there are multiple telecom operators within a given country. Currently there are six telecom operators in Bangladesh which are Grameenphone Limited, Robi Axiata Limited, Teletalk Bangladesh Limited, Banglalink Digital Communications limited, Airtel Bangladesh Limited and Citycell (Pacific Bangladesh Telecom Limited). A review on different telecom operators of Bangladesh is provided in following sub-sections (alphabetically).

2.3.3.1 Airtel Bangladesh Limited

Airtel Bangladesh Limited is a concern of Bharti Airtel Limited. Initially, in 2007 the operator was launched as “Warid Telecom Bangladesh Ltd”, which was a subsidiary of the UAE-based Abu Dhabi Group. In January 2010, Bharti Airtel Limited acquired 70% stake in Warid Telecom Bangladesh, and the operator was re-named as Airtel Bangladesh Limited. Abu Dhabi Group still continues as a strategic partner with 30% share and has nominees on the Board of the Company.

Airtel is making a new investment of USD 300 million which is being utilized for rapid expansion of the network. With this additional investment, the overall total investment in the company will be around USD 1 billion. Airtel offers a wide range of mobile services, including voice; value added services, data, m-commerce products, M-health service etc. [27].

2.3.3.2 Banglalink Digital Communications limited

Banglalink Digital Communications Limited (previously known as Orascom Telecom Bangladesh Limited) is fully owned by Telecom Ventures Ltd. (previously Orascom Telecom Ventures Limited) of Malta. Telecom Ventures Ltd. is a 100% owned subsidiary of Global Telecom Holding (GTH). According to the business combination in April 2011 between Vimpelcom ltd. and Wind Telecom s.p.a, Vimpelcom owns 51.92% shares of GTH. They launched operation in February 2005 [28].

2.3.3.3 Citycell (Pacific Bangladesh Telecom Limited)

Citycell (Pacific Bangladesh Telecom Limited) was founded in Bangladesh in 1989 and arrived at market in 1993. They are the only CDMA mobile operator in the country. They use CDMA2000 1X Technology. Their ownership is divided as: Far East Telecom Limited 17.51%, Pacific Motors Limited 37.95%, SingTel Asia Pacific Investments Pte Ltd 44.54% [29].

2.3.3.4 Grameenphone Limited

Grameenphone (GP) is one of the leading telecom operator of Bangladesh which is part of Telenor Group of Norway. GP was incorporated on 10th October 1996 as a private limited company and converted to a public limited company on 25th June 2007. Their major shareholders are Telenor Mobile Communications AS (55.80%) and Grameen Telecom (34.20%). Remaining 10% shareholders include general public & other institutions.

They started operations on 26th March, 1997. They were the first operator to introduce GSM Technology in Bangladesh. It introduced value-added services such as VMS, SMS, fax and data transmission services, international roaming service, WAP, SMS-based push-pull services, EDGE, personal ring back tone and many other products and services. Grameenphone has so far invested more than BDT 26,100 crore to build the network infrastructure [30].

2.3.3.5 Robi Axiata Limited

Robi is a joint venture company between Axiata Group Berhad of Malaysia and NTT DoCoMo Inc. of Japan. It commenced operation in 1997 as Telekom Malaysia International (Bangladesh) with the brand name 'Aktel'. In 2010 the company was rebranded to 'Robi' and the company changed its name to Robi Axiata Limited.

Since its inception in 1996, Axiata Group and its predecessor Telekom Malaysia has invested around BDT 11,000 crore in the form of equity till 2012. Moreover the company has contributed almost BDT 10,000 crore to the Bangladesh Exchequer in the same period.

As a subsidiary of Axiata Berhad Malaysia , Robi draws on leading edge technology to provide its service in Bangladesh [31].

2.3.3.6 Teletalk Bangladesh Limited

Teletalk Bangladesh Limited is a public limited company, registered under the Registrar of the Joint stock companies of Bangladesh. Total shares owned by the Government of the People's Republic of Bangladesh.

Teletalk Bangladesh Limited (the “Company”) was incorporated on 26th December, 2004 as a public limited company under the Companies Act, 1994 with an authorized capital of Tk.2,000 Crore being the only government sponsored mobile phone company in the country. On the same day the Company obtained Certificate of Commencement of Business [32].

Brand logo of all 6 telecommunication operators operating in Bangladesh are presented in Figure 2:2

Grameenphone	Robi	Banglalink
Tele Talk	Airtel	Citycell

Figure 2:2 Brand logo of telecommunication operators in Bangladesh

A summary on launching and used technology of telecom operators' of Bangladesh is provided in Table 2-2.

Table 2-2 Summary of telecom operators' in Bangladesh

Name	Year of launching	Technology
Airtel Bangladesh Limited	2007 (Warid) 2010 (Airtel)	2G and 3G
Banglalink Digital Communications limited	1997 (Sheba) 2005 (banglalink)	2G and 3G
Citycell (Pacific Bangladesh Telecom Limited)	1993	2G
Grameenphone Limited	1997	2G and 3G
Robi Axiata Limited	1997 (Aktel) 2010 (Robi)	2G and 3G
Teletalk Bangladesh Limited	2004	2G and 3G

2.3.4 Spectrum allocation of existing mobile communication technologies

Cellular telecommunication networks operate on different frequency bands including 450 MHz band, 700 MHz band, 800 MHz band, 900 MHz band, 1800 MHz band, 2100 MHz band, and 2600 MHz band. Regulatory bodies of the particular country, which is BTRC (Bangladesh Telecommunication Regulatory Commission) in case of Bangladesh, generally issue "frequency band management rights" i.e. license to use frequency bands. Afterwards, operators manage and monitor the awarded spectrum i.e. frequency bands themselves [33].

As per National Frequency Allocation Plan (NFAP) of Bangladesh, spectrum of 800 MHz, 900 MHz and 1800 MHz bands are allocated for second generation (2G) mobile telecommunication services [34]. At present five operators are providing 2G service by GSM technology and one operator providing 2G using CDMA technology in 800 MHz [10]. As per 3G licensing guideline of Bangladesh, spectrum of 2100 MHz is allocated for 3G telecommunication services [35].

Mobile network frequencies allocated to operators in Bangladesh for 2G and 3G technologies are provided in Table 2-3, Table 2-4, Table 2-5 and Table 2-6, for 800 MHz, 900 MHz, 1800 MHz and 2100 MHz respectively [10, 33].

Table 2-3 Bangladesh mobile network frequencies - 800 MHz

Operator	Frequency assigned in CDMA 800 MHz (bandwidth)
Citycell	8.82 MHz

Table 2-4 Bangladesh mobile network frequencies - 900 MHz

Operator	FDD Up Link (MHz)	FDD Downlink (MHz)	Bandwidth (MHz)
Airtel	880.5 – 885.5	925.5 – 935.5	5
Teletalk	890 – 895.2	935 – 940.2	5.2
Banglalink	895.2 – 900.2	940.2 – 945.2	5
Robi	900.2 -907.6	945.2 – 952.6	7.4
GP	907.6 - 915	952.6 - 960	7.4

Table 2-5 Bangladesh mobile network frequencies - 1800 MHz

Operator	Up Link (MHz)	Downlink (MHz)	Bandwidth (MHz)
Teletalk	1710 - 1720	1805 - 1815	10
Airtel	1720 - 1730	1815 - 1825	10
Robi	1730-1737.4	1825 – 1832.4	7.4
GP	1737.4 - 1752	1832.4 - 1847	14.6
Banglalink	1752 - 1762	1847-1857	10

Table 2-6 Bangladesh mobile network frequencies - 2100 MHz

Operator	Up Link (MHz)	Downlink (MHz)	Bandwidth (MHz)
GP	1935 - 1945	2125 - 2135	10
Airtel	1945 - 1950	2135 - 2140	5
Robi	1950 – 1955	2140 – 2145	5
Banglalink	1955 – 1960	2145 – 2150	5
Teletalk	1960 - 1970	2150 - 2160	10

2.3.5 Market share analysis of telecommunication sector in Bangladesh

Currently, the total number of mobile phone subscribers reached 133.72 million at the end of December 2015. Among the operators, Grameenphone seize the highest number of subscribers with 56.67 million. Banglalink is in the second position with 32.86 million

subscriber base. Information regarding last 3 years mobile phone subscribers is provided in Table 2-7 [18, 36, 37].

Table 2-7 Mobile phone subscribers information of last 3 years

Operator	Subscriber (in Million -December 2013)	Subscriber (in Million -December 2014)	Subscriber (in Million -December 2015)
Grameenphone	47.11	51.504	56.679
Banglalink	28.838	30.9	32.865
Robi	25.38	25.289	28.317
Airtel	8.269	7.505	10.71
Citycell	1.365	1.293	1.007
Teletalk	2.822	3.86	4.143
Total	113.784	120.35	133.72

Change in subscriber percentage over the period of 2013 to 2015 is presented in Table 2-8 which clearly shows that only Citycell has lost subscriber whereas all other operators have gained subscribers and the percentage (%) change is in double digit.

Table 2-8 Change in subscriber percentage: Year 2013 to 2015

Operator	Change in Subscriber %
Grameenphone	20.3%
Banglalink	14.0%
Robi	11.6%
Airtel	29.5%
Citycell	-26.2%
Teletalk	46.8%

Above table shows that government-owned operator Teletalk has gained maximum in terms of percentage change (~47%). Considering total subscribers change in Bangladesh market, the market has gained 19.936 Million subscribers which is 17.5% increment.

A graphical representation of the above discussion on mobile phone subscriber information for year 2013 – 2015 is presented in Figure 2:3.

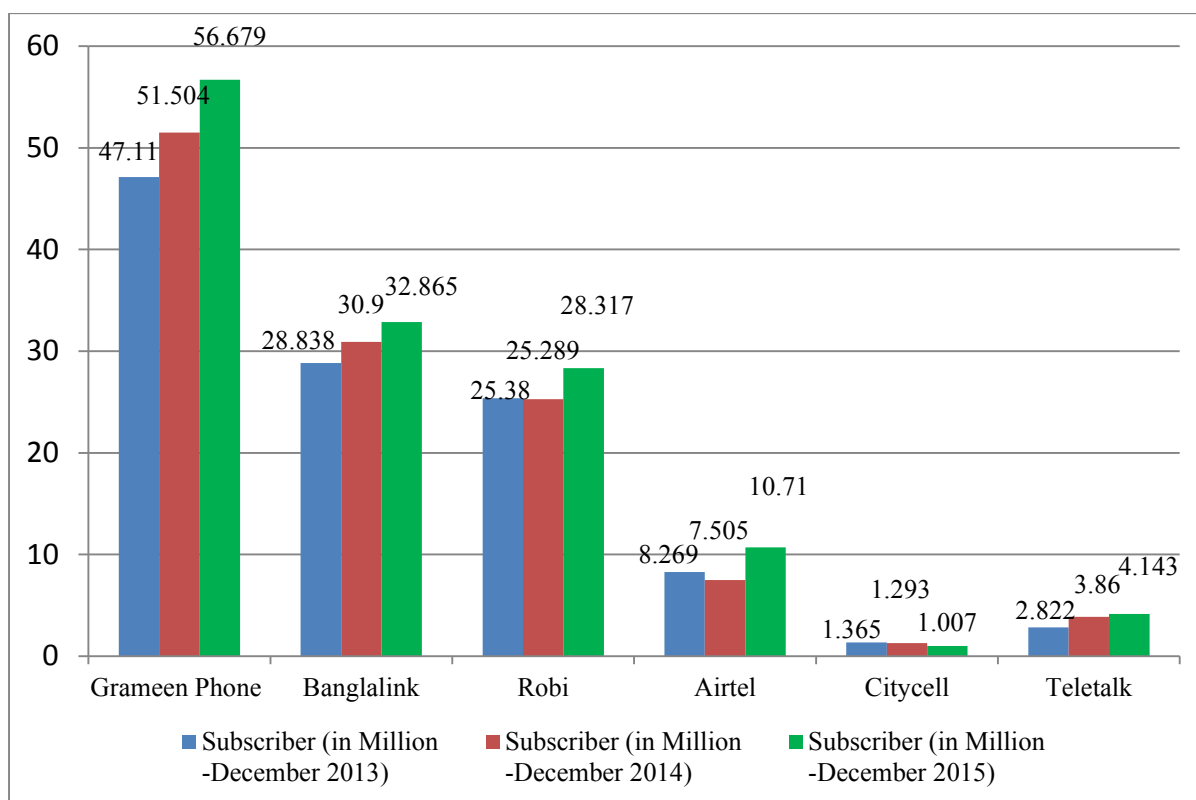


Figure 2:3 Mobile phone subscribers information: 2013-2015

The number of subscribers i.e. market share of telecom sector of Bangladesh as on December 2015 can be reviewed at a glance in Table 2-9. A graphical representation is also provided in Figure 2:4.

Table 2-9 Market share of Bangladesh telecom sector– December 2015

Operator	Subscriber (in Million) (December 2015)	Market Share (in %)
Grameenphone	56.679	42.4%
Banglalink	32.865	24.6%
Robi	28.317	21.2%
Airtel	10.71	8.0%
Citycell	1.007	0.8%
Teletalk	4.143	3.1%
Total	133.72	100.0%

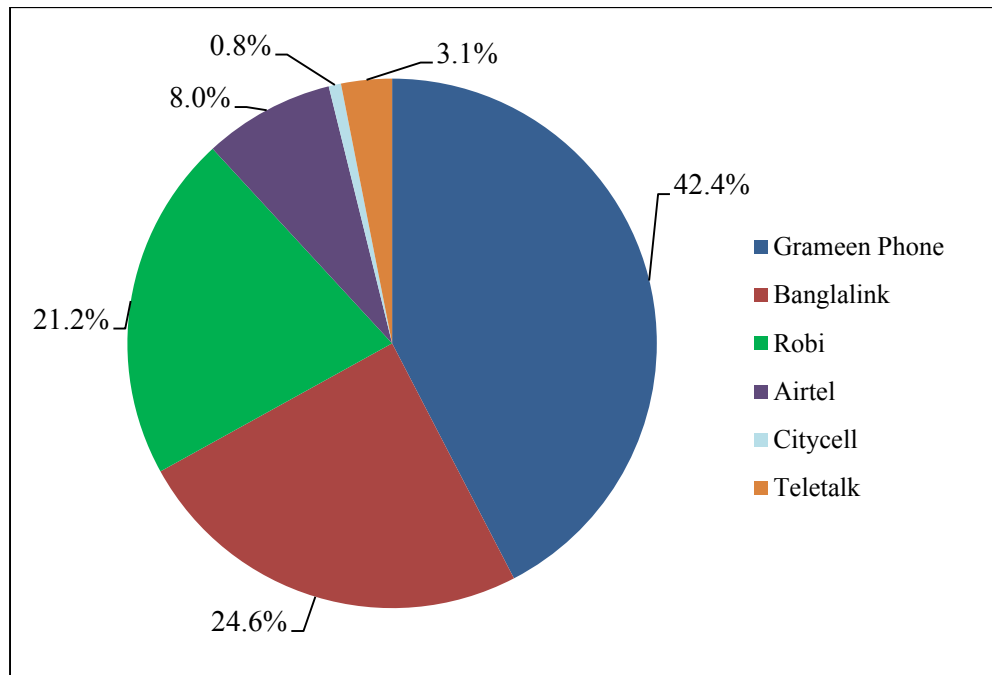


Figure 2:4 Market share of Bangladesh telecom sector– December 2015

It can be mentioned that in a research work conducted by a couple of Bangladeshi researchers in 2012, it was forecasted that the subscriber number will reach to 125.45 Million by the end of year 2016 [23]. This research work was conducted based on the growth rate of telecom market at that time. But as seen in above table the actual number of subscriber has crossed the forecasted number by 6.6%, 1 year before the expected period. This depicts the potential of telecommunication sector of Bangladesh.

2.3.6 Contribution of telecommunication sector to the economy of Bangladesh

Economic growth of a country has a positive connection with foreign direct investment (FDI). Larger FDI inflow can ensure sustainable economic growth. In Bangladesh, highest volume of foreign direct investment has been made in Telecommunication sector in recent years. In 2013-2014 fiscal years, total FDI of Bangladesh was around 1,730 million USD in which FDI in telecommunication sector was around 525 million USD, which means 30.35% of the total FDI [38].

Particularly in 2013, telecom industry invested more than 114 billion (11,400 Crore) BDT for spectrum purchase and 3G network roll-out. Over last 2 decades, telecom operators have invested more than 720 billion BDT in Bangladesh for network infrastructure development throughout the country [38].

In Fiscal years 2014-2015, Telecom operators invested around 5,664 crore (566.4 billion) BDT which is around 26% of their revenue. Detail information of operator-wise revenue and investment for fiscal years 2014-2015 is provided in below Table 2-10 [39].

Table 2-10 Telecom operators' revenue and investment: FY 2014-2015

Operator	Revenue	Investment	% (invest./Rev.)
	In Crore Taka		
Grameenphone	10,300	1,881	18%
Robi	5,058	1,825	36%
Banglalink	4,365	1,384	32%
Airtel	1,397	377	27%
Teletalk	753	197	26%
Citycell	134	Nil	N/A
Total	22,007	5,664	26%

Telecom sector also contributes in the GDP growth of Bangladesh. In fiscal years 2012-2013, contribution of this sector was 2.56% of the total GDP of Bangladesh [40]. It can be mentioned that this was one of the highest among other Asian countries. To be more specific, it was 1.8% in Malaysia and Thailand, 1% in Sri Lanka and only 0.8% in India, Indonesia and Pakistan [38]. A detail percentage-wise contribution of telecommunication sector in the GDP of Bangladesh from year 2010-11 to year 2014-15 is presented in Figure 2:5 [40]. The figure clearly shows that, for last 5 fiscal years, contribution of telecom operators in our GDP is continuously increasing.

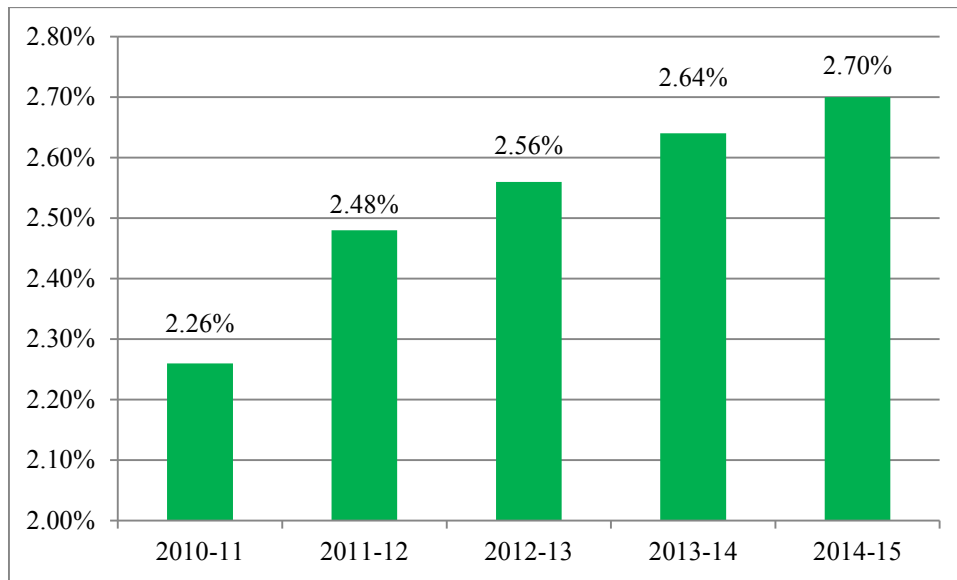


Figure 2:5 Percentage of total GDP contributed by telecom sector

According to a report published by Deloitte LLP in November 2012, due to 10% substitution from 2G to 3G penetration, GDP per capita growth increases by 0.15%. Report also stated that, if mobile data usage is doubled, GDP per capita growth increases by 0.5% [41].

2.4 Discussion on Appropriateness of Introducing 4G Technology in Bangladesh in Near Future – Need and Opportunity

With the improvement of access technology; voice, video, multimedia, and broadband data services are becoming incorporated into the same network. To achieve the targets of true broadband mobile service, telecommunication network has to make the step to 4G network. 4G is developed to provide high speed, high capacity, low cost per bit, IP based services etc. The target is to have higher data rates; 4G technology will transform wireless communications into on-line, real-time connectivity. 4G wireless technologies will allow an individual to have high-speed data communication at a very low cost [7].

Many researches have examined the success factors 3G mobile technology researchers found that there is no killer applications in 3G as there were in 2G. Killer application can

be defined as an application that beats all other competing applications; as well as it motivates users to purchase it [15]. This is a huge opportunity for 4G because the expectation from 4G technology is basically high quality audio/video streaming over end to end Internet Protocol [42].

4G technology will offer many developments to the wireless market, including downlink data rates around 100 Mbps, low latency, very efficient spectrum usage and low-cost implementations. With impressive capabilities, 4G promises to bring the customer experience to an entirely new level with extraordinary user applications, for example sophisticated graphical user interfaces, high-definition video, high-end gaming, and high-performance networks [42].

Theoretical research was done recently by two researchers on selecting an appropriate telecommunication technology for Bangladesh. In that research also it was found that 4G technology is the most preferred telecommunication technology for Bangladesh [62].

2.4.1 Advantages of 4G Technology

Some important advantages of 4G technology are mentioned below:

1. High data transmission speed: Theoretical data transmission rate of 4G can be up to 100 Mbps for high mobility and even 1 Gbps for low mobility [13].
2. Faster response time or lower latency: One benefits of 4G technology are faster response time or lower latency. LTE ensures 50% reduced round-trip latency compared to HSPA+, one of the latest 3G technology [6].
3. Smooth hand-off: 4G Technology based network will ensure smooth hand-off from one network coverage area to another without disruption to any continuing data transfer [13].

4. Less time to connect: 4G LTE ensures 95% faster connection time (i.e. requires 95% less time to connect) compared to HSPA+, one of the latest 3G technology [6].
5. Improved Security: 4G Technology offers improved security through strong communal authentication. The overall security enrichments have made 4G technology more secure than 3G technologies [12].
6. Complete Data-based Networks: 4G network is completely an IP-based data network which ensures more bandwidth that is more data transfer through the network [13].
7. Higher number of subscribers: 4G technology uses 15-digit IMSI telephone number identifiers instead of 10-digit which is used in 3G technology. So large number of devices i.e. subscribers can be connected to the network [12].

2.4.2 Applications of 4G Technology

Some key 4G applications include:

1. Faster web browsing: 4G provides much higher data speed than 3G technology which ensures much faster web browsing and considerably better surfing experience [12].
2. Live video streaming: The faster data speed of 4G technology ensures enjoying live video streaming that is watching high quality online videos without buffering [12].
3. High quality Internet calls: Using high-speed 4G technology network, subscribers can make calls using the data (i.e. internet calls) and enjoy video calls over apps like Skype, Viber etc. with better call quality and significantly reduced call-drops [12].

4. Location-based services: Provider can send real time weather or traffic conditions to smart devices, or allows finding and viewing nearby friends while communicating with them [42]. In 4G technology, remote database can contain graphical representation of streets, buildings and physical characteristics of a large metropolis. Using Tele Geo-processing, queries on location information can be answered through applications like GIS, GPS etc. [13].
5. Photo sharing with original resolution: Using 4G technology, subscribers can directly upload photos with original higher resolution via apps like Instagram, Facebook, Whats-app etc. without dropping the quality [12].
6. Mobile hotspots with higher connectivity: 4G technology has the capability to create a high speed mobile hotspot with a smart phone. Using hotspot, other devices like laptops, mobiles etc. can connect to the internet with almost similar speed. With 4G enabled mobile hotspots users can enjoy connection just like a high speed wi-fi network at home [12].
7. Portable Gaming: Currently most gaming platforms come in market with built-in Wi-Fi connectivity. Users can easily use 4G connection with several different consoles to play online games and enjoy better gaming experience than before [12].
8. Cloud-Based computing: 4G technology will provide users facility to use cloud-computing much better than 3G technology. Mobile users will be able to access cloud servers and store the data [12].
9. Tele-medicine and health service: Communication through 4G technology will ensure fast and better treatment for remote area patients using tele-medicine and online health service. Live interaction from the operation theatre will be possible [12].

2.4.3 Current deployment of 4G Technology

As per Ericsson Mobility Report - June 2015, number of 4G (LTE) subscriber globally was approximately 600 Million by March 2015 [43]. As of September 2015, the number reached to 850 Million subscriptions (Ericsson Mobility Report – November 2015) [44]. This fast growth of more than 40% addition in only 6 months shows that commercial usage of this technology is growing strongly. As forecasted, number of 4G subscriber will reach 4,100 Million globally by the end of 2021 [44].

4G has been rapidly embraced in North America, Japan and South Korea. Already in 2013 in South Korea this technology holds the majority of subscriptions. Already there are more than 350 4G network deployed all over the world. As forecasted, Asia Pacific will see 1.1 billion net additions by the end of 2020. Japan and South Korea were early adopters of 4G, and penetration in these 2 countries has reached 45% and 70% respectively. These two countries contain 20% of global 4G subscriptions, as of end of 2014. Mainland China is also having massive roll out of 4G and by the end of 2020 it will have over 1.1 billion 4G subscriptions. In Central and Eastern Europe, 4G networks have already been deployed in the most developed parts [43].

From above discussion, this is obvious that Bangladesh need to join this massive 4G Technology run in near future to cope up with the technological advancement spree of developed countries of the world.

2.5 Chapter Summary

In this chapter, a literature review is carried out to provide an overview on the telecommunications technologies like 1G, 2G, 3G and 4G technologies. Moreover, to highlight the present scenario of telecommunication technology in Bangladesh, discussion is done from different aspects like current governance structure of telecom sector of Bangladesh, existing challenges for telecom operators in Bangladesh and their profile review, spectrum allocation of existing mobile communication technologies, market share

analysis of telecom sector in Bangladesh, contribution of telecommunication sector to the economy of Bangladesh etc.

A literature review is also provided on appropriateness of introducing 4G technology in Bangladesh considering advantages and applications of 4G Technology and its current world-wide deployment.

Now in the next chapter, an overview on methodology and experimentation is provided. As a research tool of this study, Analytic Hierarchy process (AHP) is introduced in that chapter. Research model is discussed in details. Questionnaire for primary data collection is also developed in next chapter.

CHAPTER 3

OVERVIEW ON METHODOLOGY AND EXPERIMENTATION

3.1 Introduction

In this chapter, the complete methodology of this research work is described and outlined in details. This study is conducted by the milestones of working strategy finalization i.e. research model development, literature review, preparation for survey, preparation and finalization of questionnaire, conduction of survey, analysis of collected data and decision making. As a research tool of this study, Analytic Hierarchy Process (AHP) is introduced and discussed. Research model is also discussed. Questionnaire for primary data collection is also developed. Finally, as a data analysis tool, AHP online application software (AHP-OS) is also introduced and discussed.

3.2 Research Tool: Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) or Analytical Hierarchy Process has widespread application in decision-making problems which involves multiple criteria of many levels. AHP has the ability to construct complex, multi-person, multi-attribute, and multi-period problem hierarchically. AHP is very useful in case arriving at an agreed decision where several decision-makers with different conflicting objectives are involved [45].

In this research, Analytic Hierarchy process (AHP) is used as a research tool for experimental analysis. The Analytic Hierarchy Process (AHP) was stated by a prominent American expert T. L. Saaty in early 1980s [45].

3.2.1 Advantages of Analytic Hierarchy Process (AHP)

AHP is a decision-making method where the relevant elements of the problem is broken down into a hierarchy of objectives, procedures, programs, and based on this, qualitative

and quantitative analysis are conducted. It makes the people's thinking process hierarchical, quantitative and uses the mathematics to provide quantitative basis in order to analyze, decide and forecast [46].

AHP is a very effective tool because the scores and the final result both are obtained on the basis of the pairwise relative evaluations of both the criteria and the options provided by AHP user.

Computations made by AHP are always channeled by the decision maker's experience, hence AHP can be considered as a tool which is capable to translate both qualitative and quantitative evaluations into a multi-criteria ranking. In addition, AHP is simple because there is no need to build a complex expert structure with the decision maker's knowledge embedded in it [45].

Using AHP helps to gain a better insight in complex decision problems as user need to structure the problem as a hierarchy. It forces to consider possible decision criteria and select the most significant criteria with respect to the decision objective. Using pairwise comparisons helps to identify and correct logical inconsistencies. This method also permits to "translate" subjective thoughts, such as preferences or feelings, into quantifiable numeric relations. AHP helps to makes decisions more transparent and better understandable [47].

Since its origination, Analytic Hierarchy Process (AHP), has been one of the most widely used multiple criteria decision-making tools [48].

AHP is applied in different arenas such as planning, selecting best alternative, resource allocations, resolving conflict, optimization, etc. [49].

3.2.2 Elementary steps of AHP methodology

Mathematically the method is based on the solution of an Eigen value problem. The results of the pair-wise comparisons are arranged in a matrix. The first (dominant)

normalized right Eigen vector of the matrix gives the ratio scale (weighting), the Eigen value determines the consistency ratio.

Steps of AHP methodology is summarized as following [47].

- [1] Define the problem or decision required.
- [2] According to the nature of the problem and the final target, the problem is decomposed into different components i.e. factors and outcomes.
- [3] Recognize the factors that influence the behavior.
- [4] Combine these components in a hierarchy of objective, factors, sub-factors and alternatives, to form a multi-level analysis structure model.
- [5] Compare each component of the corresponding hierarchy level and calibrate them on the numerical scale. Here $m(m-1)/2$ comparisons are required, where m is the number of component with the considerations that diagonal components are equal or '1' and the other components will be the reciprocals of the earlier comparisons.
- [6] Calculate the maximum Eigen value, consistency index CI, consistency ratio CR, and normalized values for each factors and alternatives.
- [7] If the maximum Eigen value, CI and CR are acceptable then conclusion is made based on the normalized values; else the process is repeated till these values arrives at a desired level.

3.2.3 AHP implementation techniques and mathematics

Basic steps of AHP analysis are described in previous section 3.2.2. In this section AHP implementation techniques and relevant mathematics are described. In order to quantify the comparative judgment, a 1-9 scale method is introduced by AHP which is written into a form of judgment matrix. The relative importance of weights of a certain level factor related to the previous hierarchy level can be calculated from the judgment matrix. In this

way, the relative importance of weights or the ranking value of the relative merits order of the lowest level factors relative to the highest level can be calculated through top to bottom [46].

Hence AHP implementation can be done in following steps:

- (1) Compute the vector of criteria (factor) weights.
- (2) Compute the matrix of option (alternative) scores.
- (3) Arriving at the decision.

It is assumed that m evaluation criteria are considered, and n options are to be evaluated [45].

3.2.3.1 Computing the vector of criteria (factor) weights

To compute the weights for different criteria, AHP creates a *pairwise comparison matrix* $\mathbf{A}$. The matrix $\mathbf{A}$ is a $m \times m$ real matrix, where m is the number of evaluation criteria considered. For a matrix $\mathbf{A}$, a_{ij} denotes the entry in the i th row and the j th column of $\mathbf{A}$. The matrix is determined as follows:

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mm} \end{pmatrix} \quad (3.1)$$

Where, $A = (a_{ij})$, $a_{ij} > 0$, and $a_{ji} = 1 / a_{ij}$

Similarly, for a vector $\mathbf{v}$, v_i denotes the i th element of $\mathbf{v}$.

Each entry a_{jk} of the matrix $\mathbf{A}$ represents the importance of j th criterion relative to the k th criterion. If $a_{jk} > 1$, then the j th criterion is more important than the k th criterion, while if $a_{jk} < 1$, then the j th criterion is less important than the k th criterion. If two criteria have

the same importance, then the entry $a_{jk} = 1$. The entries a_{jk} and a_{kj} satisfy the following constraint:

$$a_{jk} \cdot a_{kj} = 1. \quad (3.2)$$

Obviously, $a_{jj} = 1$ for all j . The relative importance between two criteria is measured according to a numerical scale from 1 to 9, as shown in below Table 3-1, where it is assumed that the j th criterion is equally or more important than the k th criterion. The values in the matrix $\mathbf{A}$ are pairwise consistent, but the ratings may slightly inconsistent. These inconsistencies do not cause any difficulties for AHP analysis [46].

Table 3-1 AHP relative importance numerical table

The level of importance	Value assignment of a_{jk}
j and k are equally important	1
j is slightly more important than k	3
j is obviously more important than k	5
j is strongly more important than k	7
j is absolutely more important than k	9
J is not slightly more important than k	1/3
j is not obviously more important than k	1/5
j is not strongly more important than k	1/7
j is not absolutely more important than k	1/9

Note: $a_{jk} = \{2, 4, 6, 8, 1/2, 1/4, 1/6, 1/8\}$ means that the importance range among $a_{jk} = \{1, 3, 5, 7, 9, 1/3, 1/5, 1/7, 1/9\}$. These numbers are derived from people's judgment on the qualitative analysis [28].

Once the matrix $\mathbf{A}$ is built, it is possible to derive from $\mathbf{A}$ the *normalized pairwise comparison matrix* $\mathbf{A}_{\text{norm}}$ by making equal to 1 the sum of the entries on each column, i.e. each entry $\overline{a_{jk}}$ of the matrix $\mathbf{A}_{\text{norm}}$ is computed as:

$$\overline{a_{jk}} = \frac{a_{jk}}{\sum_{l=1}^m a_{lk}}. \quad (3.3)$$

Finally, the *criteria weight vector* (*Normalized Local weighted vector*) $\mathbf{w}$ (that is an m -dimensional column vector) is built by averaging the entries on each row of $\mathbf{A}_{\text{norm}}$, i.e.

$$w_j = \frac{\sum_{l=1}^m a_{jl}}{m}. \quad (3.4)$$

3.2.3.2 Computing the matrix of option (alternatives) scores

The matrix of option scores is a $n \times m$ real matrix $\mathbf{S}$. Each entry s_{ij} of $\mathbf{S}$ represents the score of the i th option with respect to the j th criterion. In order to derive such scores, a *pairwise comparison matrix* $\mathbf{B}^{(j)}$ is first built for each of the m criteria, $j=1, \dots, m$. The matrix $\mathbf{B}^{(j)}$ is a $n \times n$ real matrix, where n is the number of options evaluated. Each entry $b_{ih}^{(j)}$ of the matrix $\mathbf{B}^{(j)}$ represents the evaluation of the i th option compared to the h th option with respect to the j th criterion. If $b_{ih}^{(j)} > 1$ then the i th option is better than the h th option, while if $b_{ih}^{(j)} < 1$ then the i th option is worse than the h th option.

If two options are evaluated as equivalent with respect to the j th criterion, then the entry $b_{ih}^{(j)} = 1$.

The entries $b_{ih}^{(j)}$ and $b_{hi}^{(j)}$ satisfy the following constraint;

$$b_{ih}^{(j)} \cdot b_{hi}^{(j)} = 1, \quad (3.5)$$

and $b_{ii}^{(j)} = 1$ for all i . Evaluation scale similar to the one described in Table 3-1 may be used to interpret the decision maker's pairwise comparison into numbers.

Second, the AHP applies to each matrix $\mathbf{B}^{(j)}$ the same two-step procedure described for the pairwise comparison matrix $\mathbf{A}$, i.e. it divides each entry by the sum of the entries in the same column, and then it averages the entries on each row, thus obtaining the score vectors $\mathbf{s}^{(j)}$, $j=1, \dots, m$. The vector $\mathbf{s}^{(j)}$ contains the scores of the evaluated options with respect to the j th criterion.

Finally, the score matrix $\mathbf{S}$ is obtained as:

$$\mathbf{S} = [\mathbf{s}^{(1)} \dots \mathbf{s}^{(m)}], \quad (3.6)$$

i.e. the j th column of $\mathbf{S}$ corresponds to $\mathbf{s}^{(j)}$.

3.2.3.3 Arriving at the decision

Once the weight vector $\mathbf{w}$ and the score matrix $\mathbf{S}$ have been computed, the AHP obtains a vector $\mathbf{v}$ of global scores (Global weights of the alternatives) by multiplying $\mathbf{S}$ and $\mathbf{w}$, i.e.

$$\mathbf{v} = \mathbf{S} \cdot \mathbf{w} \quad (3.7)$$

The i th entry v_i of $\mathbf{v}$ represents the global score assigned by the AHP to the i th option. As the final step, the option ranking is accomplished by ordering the global scores in decreasing order. Hence, from all above calculation decision can be made.

3.2.4 Consistency Analysis - Checking the Consistency

When many pairwise comparisons are performed, some inconsistencies may typically arise. The objective to do consistency analysis is to make sure that the original preference ratings are consistent.

AHP includes an effective technique to check the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process, namely the matrix $\mathbf{A}$ and the matrices $\mathbf{B}^{(j)}$. The technique relies on the computation of a suitable *consistency index* (CI), and will be described only for the matrix $\mathbf{A}$. It is straightforward to adapt it to the case of the matrices $\mathbf{B}^{(j)}$ by replacing $\mathbf{A}$ with $\mathbf{B}^{(j)}$, $\mathbf{w}$ with $\mathbf{s}^{(j)}$, and m with n . The *Consistency Index* (CI) is obtained by first computing the scalar x as the average of the elements of the vector whose j th element is the ratio of the j th element of the vector $\mathbf{A} \cdot \mathbf{w}$ to the corresponding element of the vector $\mathbf{w}$. It is also called the *maximum eigen value of the matrix*. Then,

$$CI = \frac{x - m}{m - 1}. \quad (3.8)$$

A perfectly consistent decision maker should always obtain $CI=0$, but small values of inconsistency may be tolerated. In particular, if,

$$CR = \frac{CI}{RI} < 0.1. \quad (3.9)$$

The inconsistencies are tolerable, and a reliable result may be expected from the AHP. Here, RI is *Random Index* i.e. the consistency index when the entries of $\mathbf{A}$ are completely random. CR is called the *consistency ratio*.

The values of RI for small problems ($m \leq 10$) are shown in Table 3-2 [45].

Table 3-2 RI (Random Index) table for corresponding matrix size

m	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.51

3.2.5 Acceptance and adjustment of Consistency Ratio

Consistency Index and the Consistency Ratio should have been determined on the initial “pair-wise” comparisons. For perfectly consistent scenario, the consistency measures will be equal m and therefore, the CIs will be equal to zero and so will the CR. Generally, a CR value of 0.1 or below is considered acceptable. Any higher value at any level indicates the judgments need re-examination. Larger values necessitate the decision maker to reduce the inconsistencies by revising decisions. With AHP, degree of consistency can be measured; and if unacceptable, pair-wise comparisons can be revised [50].

If pairwise comparisons are not consistent; then decision-maker needs to improve the consistency. In order to derive an improved consistency, original score in the AHP 1 to 9 scales can be adjusted by the decision-maker [47].

3.3 Research Model

In this study, primary data collection is done from survey using questionnaire. Analytical Hierarchy Process (AHP) is used for the empirical analysis of data. Questionnaires are designed to get pair-wise comparison data i.e. which is required for AHP analysis. Some general questions are also included in the questionnaire results of which also contributed to reach the objective of the research.

3.3.1 Source of data

Required primary data are collected from a survey using questionnaire which is performed by written survey. The survey is conducted among selected experts in telecommunication domain of Bangladesh. Secondary data are collected from papers, journals, related studies, documents, books, internet and newspaper review and other sources of information.

3.3.2 Sampling design (Sampling technique and sample size)

For this study, respondents i.e. experts are selected from telecommunication domain of Bangladesh. Selective sampling method is used based on selective criteria [51]. Experts selected for this research are divided into two categories– industry experts and independent experts.

For sampling the industry experts, four selective criteria are considered to ensure experienced experts with adequate knowledge in telecommunication domain of Bangladesh are chosen. These criteria are defined as following:

Firstly, respondents are directly connected to anyone of the following: telecommunication operators, network equipment vendors and local services providers

(LSPs) of Bangladesh. Directly connected means respondent is employee or owner or major shareholder of the respective organization. LSPs are local organizations providing telecommunication support services like installation, commissioning, operations, maintenance etc. to operators and in some cases to equipment vendors as well.

Secondly, respondents have more than 5 (five) years of professional experience (in telecommunication domain). This will ensure that the selected experts have observed both pre-3G and post-3G era.

Thirdly, respondents are at least graduate in any discipline.

Fourthly, respondents have decision making or at least recommendation making authorization in respective organization.

Independent experts are selected from universities and regulatory commission. Independent experts' opinion are also very critical as they can provide independent opinion from a third eye view. University experts' opinion is important due to their academic knowledge about technology. As the formulated strategy must comply all regulatory issues so while formulating strategy, considering regulatory commission's opinion is also important. Following selective criteria are considered to ensure appropriate experts to provide required opinion are selected. These criteria are defined as below:

For university experts:

Firstly, respondents are researchers in telecommunication domain working in any reputed university of Bangladesh.

Secondly, respondents hold designation of at least Assistant Professor (or above).

Thirdly, respondents have already completed Doctorate degree.

For experts from regulatory commission:

Firstly, respondents are working in Bangladesh Telecommunication Regulatory Commission (BTRC).

Secondly, respondents hold designation of at least Assistant Director (or above).

Sample size is 40 (forty) that means survey is conducted to 40 experts.

The sampling design is summarized in following Table 3-3:

Table 3-3 Summary of sampling design

Sampling Technique	Selective Sampling method
Target Population	Experts in Telecommunication domain of Bangladesh
Sample Type and Selection	a. Industry Experts; Selected from: - telecommunication operators - network equipment vendors - local service providers b. Independent experts; Selected from: - universities - regulatory commission
Number of Experts	40 (Forty)
Scaling Technique	AHP 1 – 9 scale
Extent	Dhaka, Bangladesh

3.3.3 Development of AHP model

In AHP method, relevant elements of the problem are broken down into a hierarchy. In this AHP model four steps are used for data hierarchy namely objective, factors, sub-factors and alternatives. These steps are designed according to the nature of the problem described in this study.

First stage comprises the research objective (i.e. identification of critical factors, formulation of a strategic plan and development of an adoption model for successful adoption 4G technology by telecommunication operators in Bangladesh) which is then

decomposed into different factors (i.e. criteria), sub-factors (i.e. sub-criteria) and alternatives in following steps. Second step contains the three factors i.e. criteria to be considered for decision making i.e. strategy formulation, and third step contains sub-factors i.e. sub-criteria. Ten numbers of sub-factors are selected in this research for ranking three alternatives as primary 4G Technology adoption strategy mentioned in the fourth step.

The steps of AHP model are summarized in Table 3-4. The model is designed following the methods described earlier in section 3.2.

Table 3-4 Stages of AHP hierarchy

Step-1: Objective	Identification of critical factors, formulation of a strategic plan and development of an adoption model to successfully adopt 4G technology by telecommunication operators in Bangladesh
Step-2: Factors (Criteria)	1. Technology 2. Sales and Marketing 3. Ripple effect
Step-3: Sub-factors (Sub-criteria)	1. Network coverage and quality 2. Technological up-gradation 3. Knowledge development 4. Advertising and branding 5. Customer classification and analysis 6. Product, packages and pricing 7. After-sales customer service 8. Social impact 9. Economic impact 10. Customer response
Step-4: Alternatives	1. Voice service 2. Data service 3. Value Added Services (VAS)

The criteria (factors) and sub-criteria (sub-factors) are the structural blocks of AHP as shown in above table. Based on the above four level hierarchy, Relevance Tree (RT) is formed as shown in Figure 3:1. Pair-wise comparison matrices are developed from this Relevance Tree which are then used in the questionnaire.

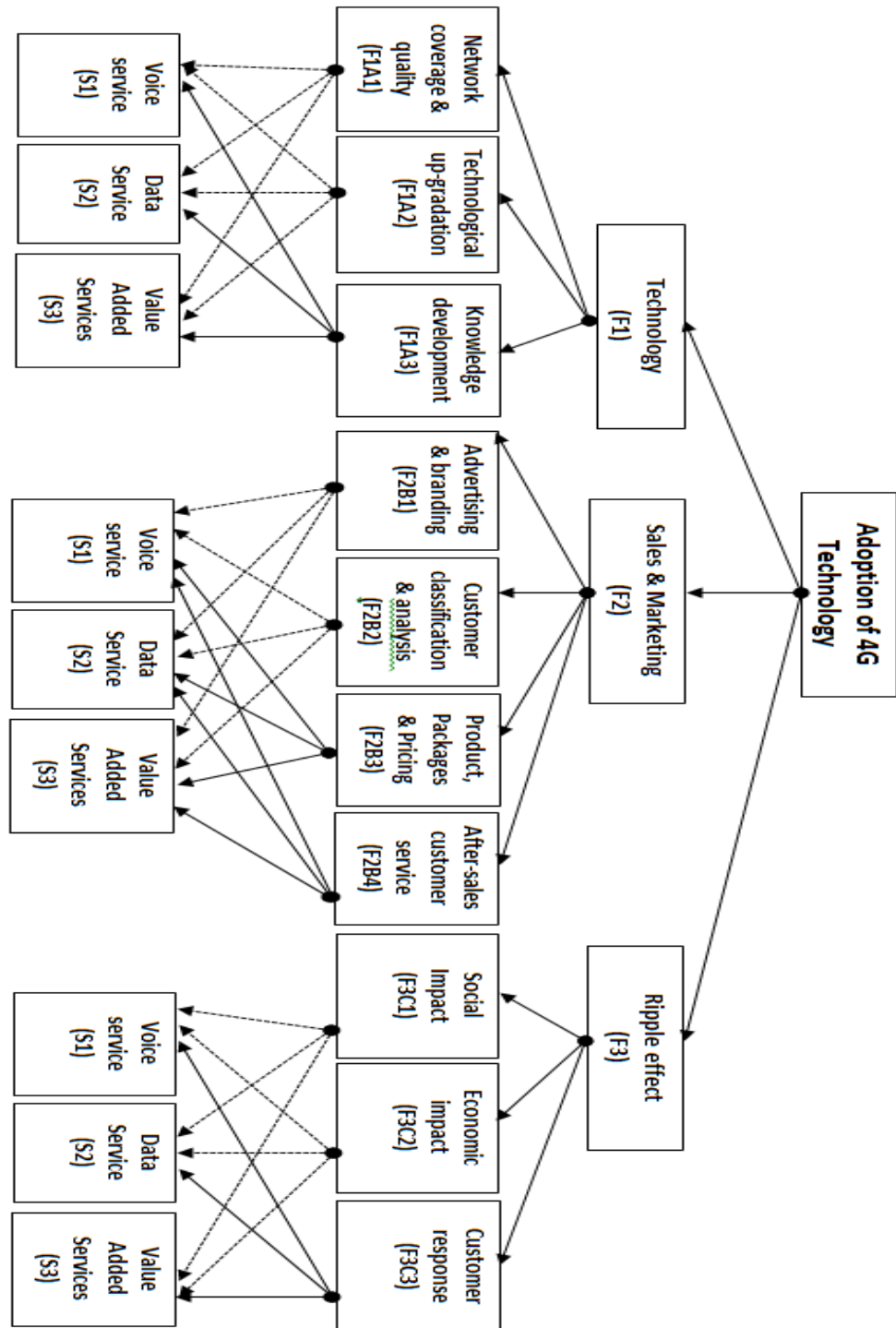


Figure 3:1 Criteria and sub-criteria based AHP Relevance Tree

3.3.4 Questionnaire development

For primary data collection and empirical analysis a questionnaire is developed. The questionnaire is divided into three parts. All the parts are designed keeping in mind the objectives and expected outcomes of the thesis i.e. examining the appropriateness of introducing 4G technology in Bangladesh in near future, identification of critical factors, formulation of a strategic plan and development of a model to successfully adopt 4G technology by telecommunication operators in Bangladesh.

Part 01 contained questions with multiple options. Part 02 is the major part containing pair-wise comparison table which is the AHP based questionnaire. Part 03 contained open-ended questions to collect experts' open opinion.

3.3.4.1 Questions provided in part 01 of the questionnaire

Part 01 contained general questions with multiple options. Following are the questions:

- 1) "Do you think telecom consumers are satisfied with the 2G and 3G services available in Bangladesh?" Objective of this question is to find out expert opinion on customer satisfaction on existing telecommunication technologies. Options are:
 - Strongly disagree
 - Disagree
 - Neutral
 - Agree
 - Strongly agree

- 2) "Do you think that introduction of 4G technology will give consumers better mobile communication experience than existing 2G / 3G technology?" Objective of this question is to find out expert opinion on appropriateness of introducing 4G technology from customer experience perspective. Options are:
 - Strongly disagree
 - Disagree
 - Neutral
 - Agree
 - Strongly agree

- 3) “Do you agree that introduction of 4G technology in Bangladesh will bring success (i.e. positive business case) for countries’ telecommunication operators?”

Objective of this question is to find out expert opinion on appropriateness of introducing 4G technology from operators’ business perspective. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

- 4) “When do you think it will be appropriate to introduce 4G Technology in Bangladesh?”

Objective of this question is to find out expert opinion on appropriate timeline of introducing 4G technology in Bangladesh. Options are:

- 0 – 1 year
- 1 – 2 years
- 2- 3 years
- 3 – 4 years
- Later than 4 years

- 5) “Do you think availability of 4G enable handset will be a challenge for 4G growth?”

Objective of this question is to find out expert opinion on whether 4G enable handset is a challenge or not for introduction of 4G technology. Options are:

- Yes
- No

- 6) “Do you think customers will welcome the introduction of 4G Technology?”

Objective of this question is to find out expert opinion on probable customer response upon introduction of 4G technology in Bangladesh. Options are:

- Yes
- No

- 7) “During initial stage of 4G technology roll-out, which geographical location do you think operators should focus?”

Objective of this question is to find out expert opinion on focus geographical area for 4G technology launching in Bangladesh.

Result of this question contributes to formulate the 4G technology adoption strategy.

Options are:

- Metropolitan areas
- Urban areas
- Sub-Urban areas
- Rural areas
- All over the country

- 8) “As 2G and 3G will be running i.e. revenue generating business for operators during 4G roll-out, which of the below should be most appropriate approach for operators?” Objective of this question is to find out expert opinion on business continuity approach during 4G technology launching in Bangladesh. Result of this question contributes to formulate the 4G technology adoption strategy. Options are:

- All focus on 4G – no focus on 3G 2G
- Major focus on 4G - little focus on 3G and 2G
- Equally major focus on 4G and 3G – less focus on 2G
- Equal focus on 4G, 3G, 2G

- 9) “What will be the most appropriate market acquisition approach for 4G adoption?” Objective of this question is to find out expert opinion on market acquisition approach during 4G technology launching in Bangladesh. Result of this question contributes to formulate the 4G technology adoption strategy. Options are:

- Extremely Aggressive & Innovative
- Moderately aggressive
- Business as usual (BAU)
- Slower than BAU

- 10) “Which age-group do you think will be major potential customer for 4G technology?” Objective of this question is to find out expert opinion on potential customer age-group for 4G technology business in Bangladesh. Result of this question contributes to formulate the 4G technology adoption strategy. Options are:

- 18 – 29
- 30 – 49
- 49 – 64
- 65+

- 11) “Do you agree that introduction of 4G technology will create positive impact on socio-economic activities in the country?” Objective of this question is to find out

expert opinion on impact of introducing 4G technology on socio-economic activities in the country. Result of this question contributes to find out appropriateness of introducing 4G technology from country's socio-economic perspective. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

12) “Do you think 4G pricing need to be more attractive than existing 2G and 3G pricing?” Objective of this question is to find out expert opinion on pricing strategy for 4G technology business in Bangladesh. Result of this question contributes to formulate the 4G technology adoption strategy. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

13) “Do you think existing after-sales customer service need to be more improvised while adopting 4G technology?” Objective of this question is to find out expert opinion on after-sales customer service for 4G-business in Bangladesh. Result of this question contributes to formulate the 4G technology adoption strategy. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

14) “Do you think customer knowledge base on 4G technology need to be improved through campaign while adopting this new technology?” Objective of this question is to find out expert opinion on customer knowledge on 4G technology. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

15) “Do you think innovative product development is crucial while adopting this new 4G technology?” Objective of this question is to find out expert opinion on innovative product for 4G technology business. Result of this question contributes to formulate the 4G technology adoption strategy. Options provided are given below:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Above fifteen questions are common for all experts. Independent experts are asked two extra questions in this part which are on harmful i.e. negative impact of growth of telecommunication technology throughout any country. Independent experts can provide neutral and open opinion in this point. Result of these questions contributes to formulate the 4G technology adoption strategy. Following are these two questions:

16) “Do you think telecom operators need to consider geographical location, congestion of sites, appropriate distance etc. while installing new sites during introduction of this new 4G technology?” Objective of this question is to find out expert opinion on planned installation of telecom sites. Options are:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

17) “Do you think telecom operators need to consider environmental impact and levels of Electro Magnetic Field (EMF) Radiation from mobile towers while adopting this new 4G technology?” Objective of this question is to find out expert opinion on consideration of environmental impact of telecom technologies. Options are

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

3.3.4.2 Questions provided in part 02 of the questionnaire

Part 02 i.e. the AHP pair-wise comparison table is formed based on the Relevance Tree provided in Figure 3:1. At first the questionnaire is prepared for general criteria, then for sub-criteria and then alternatives. The questionnaire and scale considered for this study is from 1 (Equally Preferred) to 9 (Extremely Preferred). AHP standard preference table is given in Table 3-5 for detail of scale 1-9.

Table 3-5 Pair-wise comparison scale for AHP preferences

AHP (Analytical Hierarchy Process) Standard Preference Table	
Judgments of preference	Numerical Rating
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Questions are generated in pair-wise comparisons among the parameters presented in Table 3-4. There are in total 45 questions. Some sample questions of this part are presented below. Detail questionnaire is provided in Appendix section.

Some sample questions regarding pair-wise comparison of criteria and sub-criteria:

1 (a) To adopt 4G technology by Bangladeshi Telecom operators, which factor do you think is most important: Technology (F1) or Sales & Marketing (F2) ? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

2 (a) To adopt 4G technology by Bangladeshi Telecom operators, which factor do you think is most important: Technology (F1) or Ripple Effect (F3) ? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

3 (a) To adopt 4G technology by Bangladeshi Telecom operators, which factor do you think is most important: Sales & Marketing (F2) or Ripple Effect (F3) ? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

4 (a) Given the Factor F1 (Technology), which sub-factor do you think is most important: Network coverage & quality, (F1A1) or Technological up-gradation, (F1A2)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

5 (a) Given the Factor F1 (Technology), which sub-factor do you think is most important: Network coverage & quality, (F1A1) or Knowledge development, (F1A3)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

6 (a) Given the Factor F1 (Technology), which sub-factor do you think is most important: Technological up-gradation, (F1A2) or Knowledge development, (F1A3)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

Some sample questions regarding pair-wise comparison of alternatives:

43 (a) Given the sub-factor Customer response (F3C3), which alternative do you think is most important: Voice service (S1) or Data Service (S2)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

44 (a) Given the sub-factor Customer response (F3C3), which alternative do you think is most important: Voice service (S1) or Value Added Services (S3)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

45 (a) Given the sub-factor Customer response (F3C3), which alternative do you think is most important: Data Service (S2) or Value Added Services (S3)? **Ans:**

(b) Please indicate, on a scale from 1 to 9 to what extent you consider your choice is more important than the other one. **Ans:**

To be mentioned that format of answering the questions are slightly modified in the actual questionnaire for better understanding and proper feedback. The actual questionnaire which is supplied to experts for feedback is provided in the appendix section.

3.3.4.3 Questions provided in part 03 of the questionnaire

Part 03 contained few open-ended questions as following:

- 1) “Please mention some risks, barriers, difficulties etc. to implement and adopt 4G technology.”
- 2) “Please give your open opinion about 4G technology implementation in Bangladesh.”

Above two questions are common for all experts. Independent experts are asked one extra questions in this part which is on harmful i.e. negative impact of growth of telecommunication technology throughout any country. Independent experts can provide neutral and open opinion in this point. Following is the question:

- 3) “Please provide your open comments regarding considerations of environmental impact while adopting this new 4G technology?”

Answer to these questions are treated as general feedback of experts. These feedbacks are also used to formulate the strategy for successful adoption of 4G technology by telecom operators in Bangladesh.

Detail questionnaire (which is supplied to experts to fill-up) is provided in appendix section.

3.3.5 Data collection

Data are collected from written survey conducted to 40 experts. Expert sampling is done as mentioned in section 3.3.2.

3.3.5.1 Demographic analysis of experts

Experts selected for this research are divided into two categories– industry experts and independent experts. Survey is conducted to 30 industry experts and 10 independent experts.

Out of 30 industry experts, 14 are from telecom operators, 11 are from local service providers and 5 are from equipment vendors. Among 30, 20 of them have Bachelor degree and 10 of them have Master's degree. Total year of experience for all 30 experts is 293.5 years that is average experience is 9.78 years per expert.

Out of 10 independent experts, 5 are from 2 different universities and 5 are from Bangladesh Telecommunication Regulatory Commission (BTRC). Among experts from universities, 2 are Associate Professor and 3 are Assistant Professors. All of them have Doctorate degree. Among experts from BTRC, 4 are Senior Assistant Directors and 1 is Assistant Director.

Above demographic analysis shows that a good mixture of experienced experts are selected for this research which ensured feedback from different point of view.

Detail demographic information of the experts is given in Appendix section.

3.3.6 Data analysis

After primary data-collection through survey, data analysis is done. To analyze part 02 i.e. AHP pair-wise comparison analysis, matrix of general criteria is formed by administering those data. Under these general criteria there are some sub-criteria. These sub-criteria are compared under each general criterion.

Collected data are administered for every sub-criterion under every general criterion. Every sub-criterion has three alternatives or options. The alternatives are compared pair-wise considering the sub-criteria under general criteria through administering into the

matrix. All these comparisons give a number of tables of conforming matrix with corresponding values. At each stage consistency is checked for authentic result.

Finally the data analysis is done using AHP online software (AHP-OS) and Microsoft excel spread sheet [47, 52]. Part 01 data is analyzed using Microsoft excel spread sheet and part 03 is studied as discussion on experts' open opinion.

3.3.7 Introduction to AHP Online Application Software

For AHP data analysis, AHP online application software (AHP-OS) available at BPMSG's website is used [47, 53]. Abbreviation of BPMSG is "Business Performance Management Singapore". This site is a non-commercial website, and information is shared for educational purposes.

AHP-OS is a web-based analysis tool which helps rational decision making based on Analytic Hierarchy Process (AHP). It allows defining a hierarchy of criteria for a decision problem, to calculate priorities and evaluate a set of decision alternatives against those criteria. Criteria weights and ranking of alternatives for a decision problem are calculated based on pairwise comparisons.

AHP online tool has features to manage complete AHP projects as well as priorities i.e. pair-wise comparative importance for different criteria, sub-criteria and alternatives [54, 55]. These tools can store complete decision hierarchies and then use them to estimate the weights of criteria and sub-criteria and evaluate up to ten decision alternatives. In this tool, results can be exported as .csv (Comma Separated Values) files for further processing in spreadsheet programs. For this thesis, the latest available online version [version 2015-11-15] during study work is used.

3.4 Chapter Summary

In this chapter, an overview on methodology and experimentation is provided. Research tool (AHP) and research model (including expert sampling, data collection, questionnaire

development etc.) are discussed in details. Questionnaire for primary data collection is also prepared in this chapter. Finally, an introduction is given on the AHP data analysis tool named AHP online application software (AHP-OS).

Next, Chapter 4 focuses on empirical analysis, results and discussion. Detail analysis of the primary data collected through survey is provided. Identification of critical factors and formulation of a strategic plan to adopt 4G technology by telecommunication operators in Bangladesh are presented. A model to adopt 4G technology by telecommunication operators in Bangladesh is also developed in that chapter.

CHAPTER 4

EMPIRICAL ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

In the last chapter research tool and research model are discussed in details. Also, AHP data analysis tool named AHP online application software (AHP-OS) is introduced.

In this chapter detail analysis of the primary data collected through survey is provided. Final results and discussion are the main contents of this chapter. Identification of critical factors and formulation of a strategic plan to adopt 4G technology by telecommunication operators in Bangladesh are presented. A model to adopt 4G technology by operators in Bangladesh is also developed in this chapter.

4.2 Result Calculation, Analysis and Discussion

As discussed in Chapter 3, questionnaire is divided into three parts. Part 01 contained questions with multiple options. Part 02 is the major part containing pair-wise comparison table which is the AHP based questionnaire. Part 03 contained open-ended questions to collect experts' open opinion. All the parts are designed keeping in mind the objectives of the thesis i.e. examining the appropriateness of introducing 4G technology in Bangladesh in near future, identification of critical factors, formulation of a strategic plan and development of a model for successful adoption of 4G technology by telecommunication operators in Bangladesh. Here, the results of survey are analyzed and discussed in following sections considering the research objectives.

The data analysis is completed using Microsoft Excel Spread Sheet and AHP Online Software.

4.3 Analysis of Experts' Opinion on Appropriateness of Introducing 4G Technology in Bangladesh in Near Future

Previously in Chapter 2 a literature review is provided on the appropriateness of introducing 4G technology in Bangladesh in near future. Here in this section this issue is discussed based on the analysis of all (industry and independent) experts' opinion collected through survey for this research work.

To examine the appropriateness of introducing 4G, at first it is necessary to understand consumer satisfaction level on existing 2G and 3G services. Hence experts are asked: “Do you think telecom consumers are satisfied with the 2G and 3G services available in Bangladesh?” Results of the survey are shown in Figure 4:1.

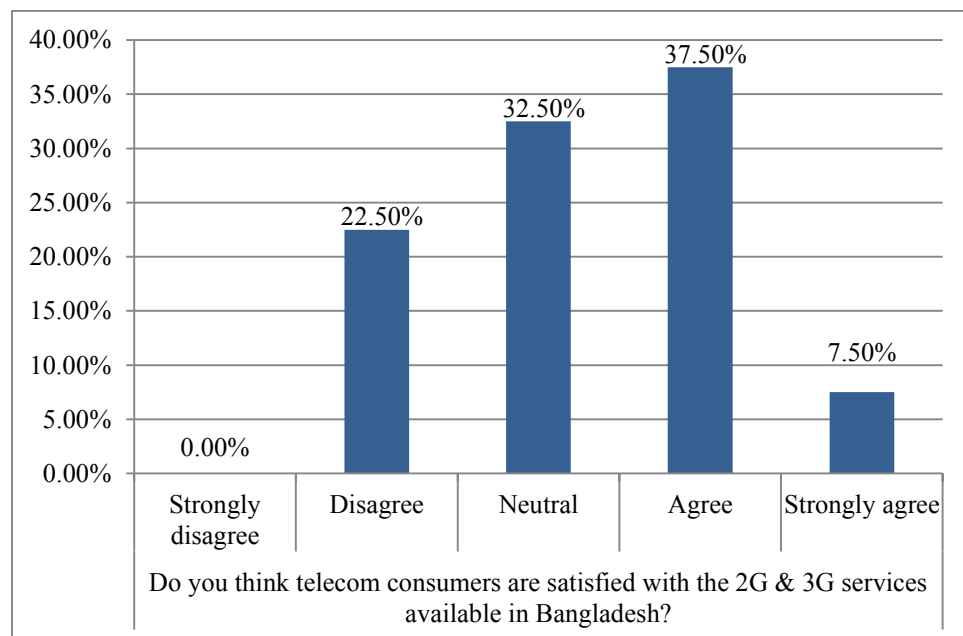


Figure 4:1 Experts' opinion- consumers' satisfaction with existing technologies

From the figure it is clear that though 45% of the experts supported the statement that “consumers are satisfied with the 2G and 3G services available” (Agree- 37.50% and Strongly Agree- 7.50%), but other 55% of the experts either completely “Disagree” with the statement (22.50%) or “Neutral” to support the statement (32.50%). This depicts that experts' are not comprehensively supporting the statement. Hence based on the combined

opinion of the experts it can be said that, customers are not completely satisfied with existing technologies.

Next, to find out expert opinion on appropriateness of introducing 4G technology from customer experience perspective, experts are asked: “Do you think that introduction of 4G technology will give consumers better mobile communication experience than existing 2G / 3G technology?” Results of the survey are shown in Figure 4:2.

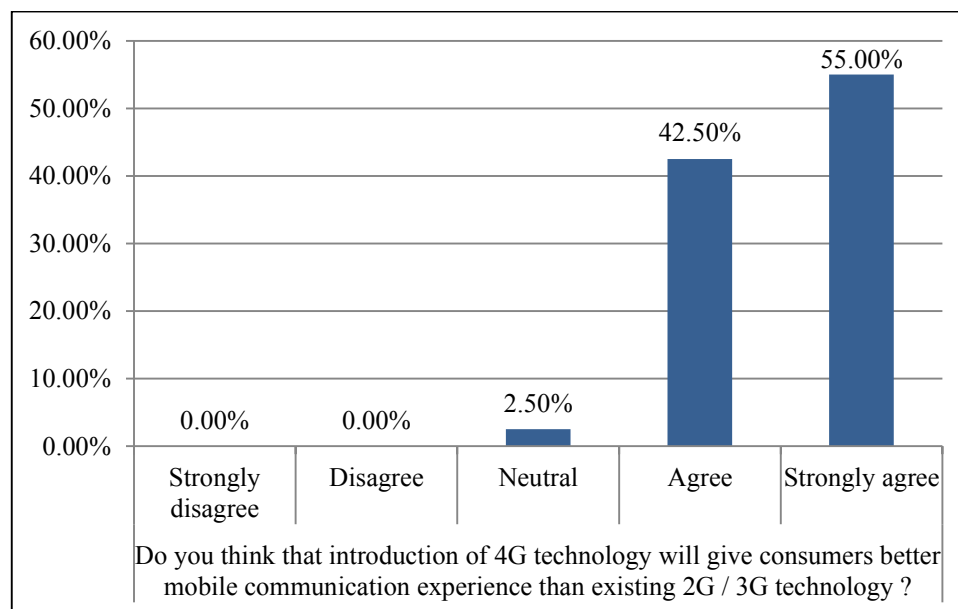


Figure 4:2 Experts’ opinion- changes in consumer experience upon introduction of 4G technology

From the above figure it is clear that maximum number of experts agreed with the statement that “Introduction of 4G technology will provide consumers better mobile communication experience” as 55% experts responded “Strongly Agree” with the statement and 42.50% experts responded “Agree”. So, based on expert opinion it can be said that from consumer experience perspective, it will be appropriate to introduce 4G technology in Bangladesh.

To formulate a strategy for successful adoption of 4G technology, it is also required to know experts’ opinion on appropriateness of introducing 4G technology from operators’ business perspective. Experts are asked: “Do you agree that introduction of 4G

technology in Bangladesh will bring success (i.e. positive business case) for countries' telecommunication operators?" Results of the survey are shown in Figure 4:3.

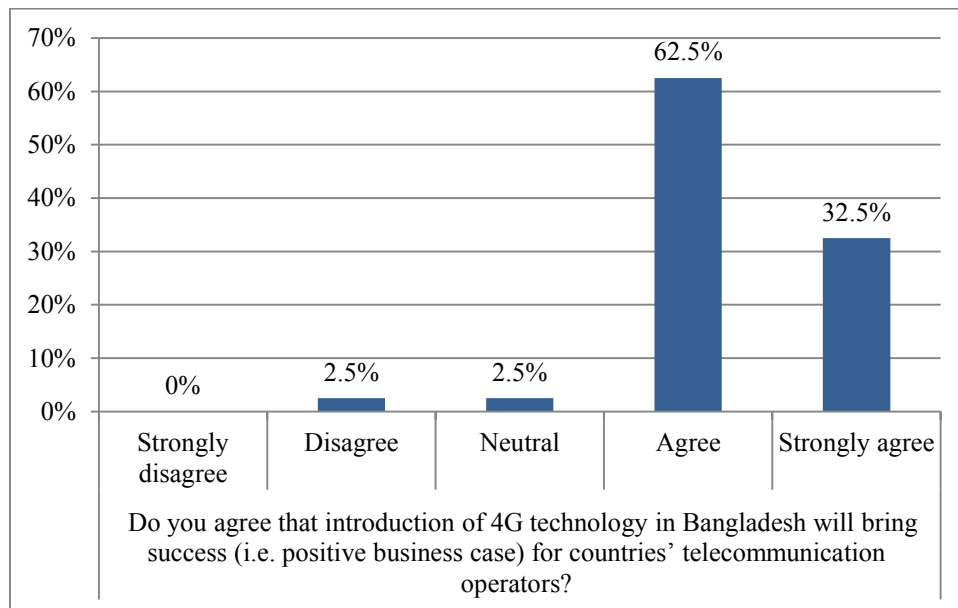


Figure 4:3 Experts' opinion- possibility of success for operators through introduction of 4G technology

Above figure shows that, 95% experts agreed with the statement that “4G technology in Bangladesh will bring success (i.e. positive business case) for countries' telecommunication operators” as 32.5% experts opined “Strongly Agree” and 62.5% opined “Agree”. Only 2.5% i.e. only 1 expert out of 40 disagreed and another expert opined “neutral” which are very nominal. Hence based on expert opinion, it can be said that it will be appropriate to introduce 4G technology in Bangladesh from operators' business perspective also.

It is also very crucial to find out experts' opinion on tentative appropriate timeline to introduce 4G technology. In this regard, experts are asked: “When do you think it will be appropriate to introduce 4G Technology in Bangladesh?” Results of the survey are shown in Figure 4:4.

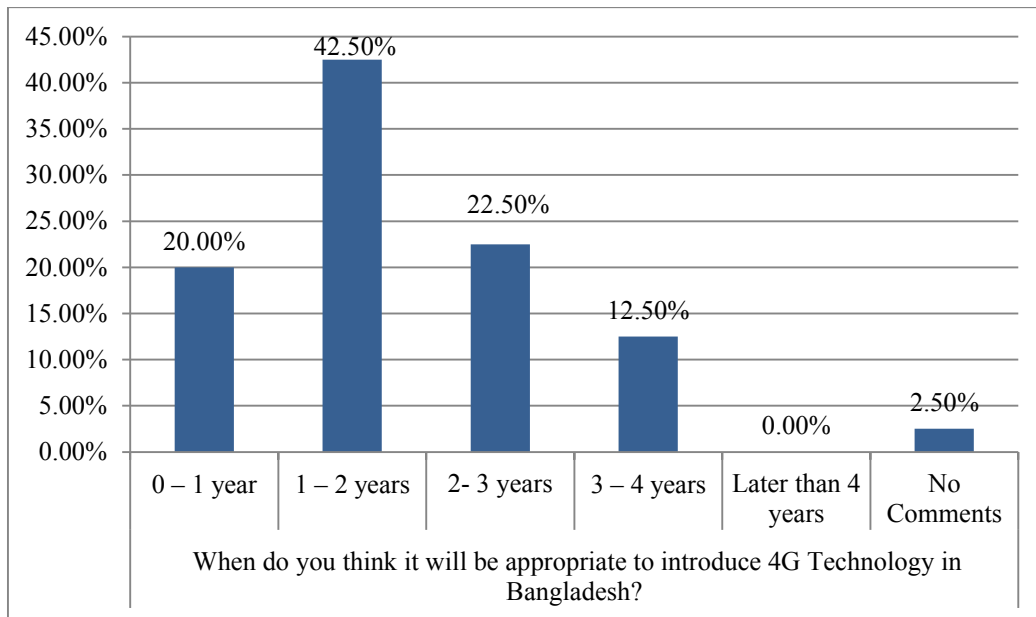


Figure 4:4 Experts’ opinion- appropriate timeline to introduce 4G technology

Above figure shows that all experts who responded against this question (39 out of 40 experts) supported that 4G technology need to be introduced in Bangladesh in less than 4 years (from the period of study) where maximum (43%) supported that the appropriate timeline will be within 1 to 2 years (from the period of study). Hence, based on experts’ opinion it can be said that the appropriate time to introduce 4G technology in Bangladesh is in between 2016 to 2017.

Next the study moved to find out experts’ opinion on probable customer response upon introduction of 4G technology in Bangladesh. This is very crucial to understand before launching a new technology. The question asked to experts in this regard is: “Do you think customers will welcome the introduction of 4G Technology?” Results of the survey are shown in Figure 4:5.

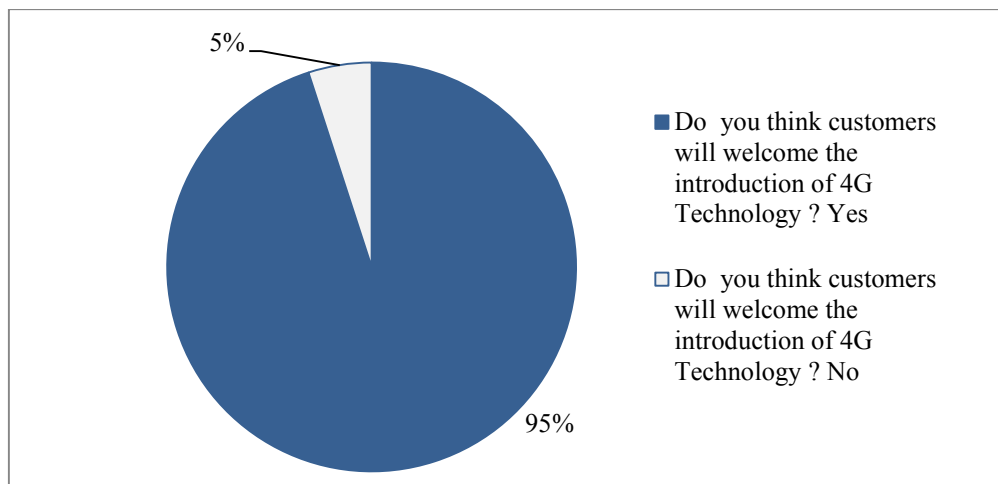


Figure 4:5 Experts' opinion- probable consumer response to introduction of 4G technology

Above figure shows that 95% experts opined that introduction of 4G technology will be appreciated by customers. This is a good sign and supports the appropriateness of introducing 4G Technology in Bangladesh in near future.

It is also essential to find out impact of introducing 4G technology on socio-economic activities in the country. In this regard, experts are asked: “Do you agree that introduction of 4G technology will create positive impact on socio-economic activities in the country?” Results of the survey are shown in Figure 4:6.

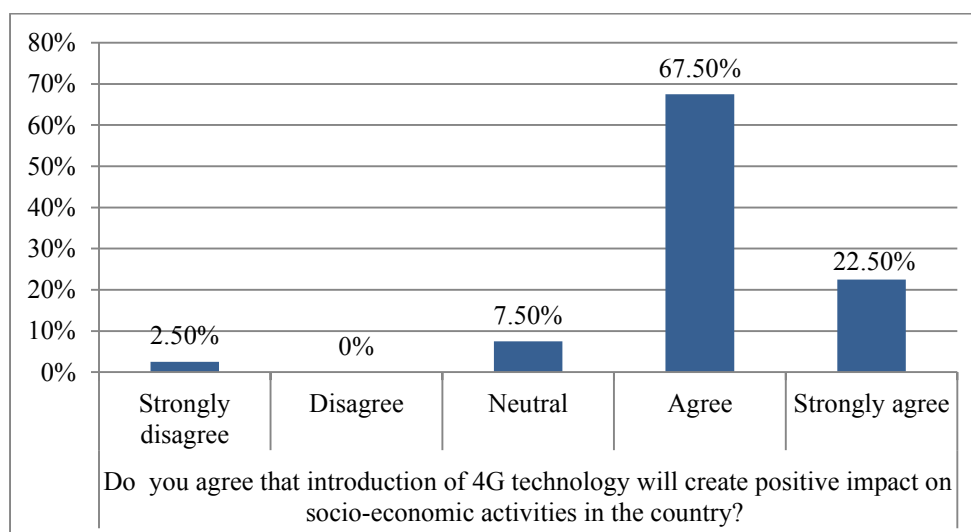


Figure 4:6 Experts' opinion- impact on socio-economic activities

Figure shows that a large majority of the experts (Agree- 67.50% and Strongly Agree – 22.50%; that means a total of 90%) supported that introduction of 4G technology will create positive impact on socio-economic activities. This is also a good sign and supports the appropriateness of introducing 4G Technology in Bangladesh in near future.

4.4 Analysis of Expert Opinion on Challenges of Introducing 4G Technology in Bangladesh

A crucial objective of this research work is to identify different challenges i.e. risks, barriers, and difficulties for telecommunication operators in Bangladesh to implement and adopt 4G technology. In this regard, experts are asked several questions in the survey. Next, results against these questions are provided and experts' opinion are analyzed to identify the challenges.

One crucial item to use any communication technology is the device or handset. It is necessary to find out how crucial the availability of 4G enable handset is for 4G technology adoption. Experts are asked: “Do you think availability of 4G enable handset will be a challenge for 4G growth?” The result is shown in Figure 4:7.

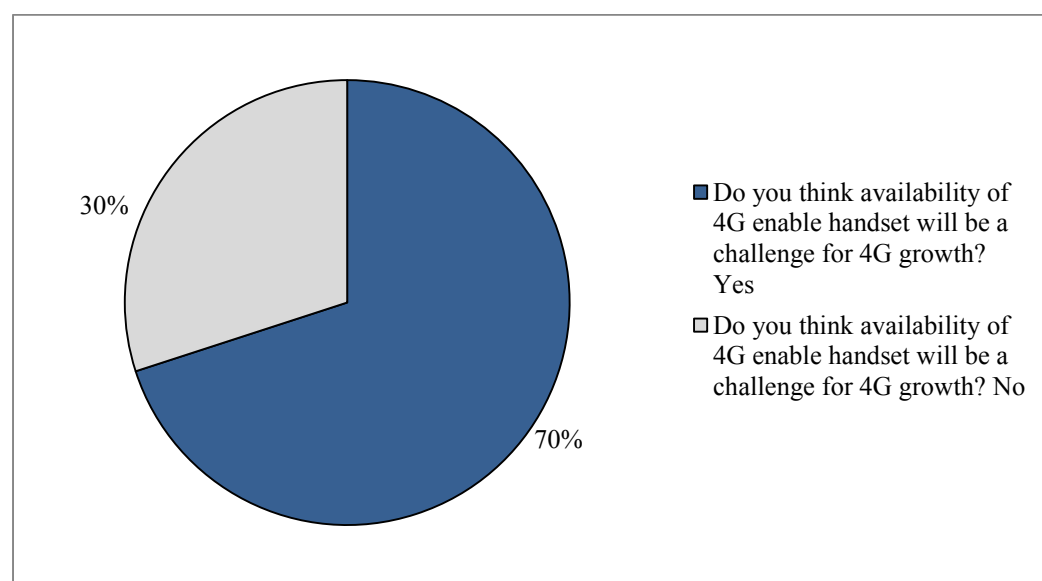


Figure 4:7 Experts' opinion- 4G enable handset as a challenge

Figure shows that a large majority of the experts (70%) opined that 4G enable handset will be a challenge for telecommunication operators in Bangladesh to introduce and adopt 4G technology.

Appropriate pricing is a crucial factor for any business and setting appropriate strategy for proper pricing can be a difficulty for the operators. In this regard, experts are asked: “Do you think 4G pricing need to be more attractive than existing 2G and 3G pricing?” Result of this question is given in Figure 4:8.

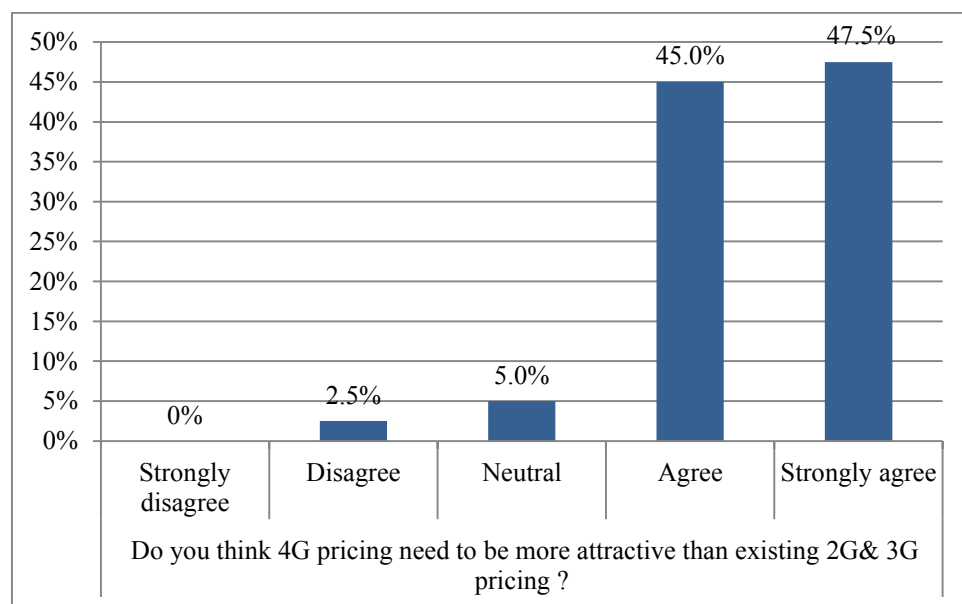


Figure 4:8 Experts’ opinion- 4G Pricing in comparison with 2G and 3G

Figure shows that a large majority of the experts (Agree- 45.0% and Strongly Agree – 47.5%; total 92.5%) supported the statement “4G pricing need to be more attractive than existing 2G and 3G pricing”. This can be a great risk for operators besides maintaining profit. However this is a critical strategy for achieving success.

Customer service is very important for any business. In this regard, experts are asked: “Do you think existing after-sales customer service need to be more improvised while adopting 4G technology?” Results are shown in Figure 4:9.

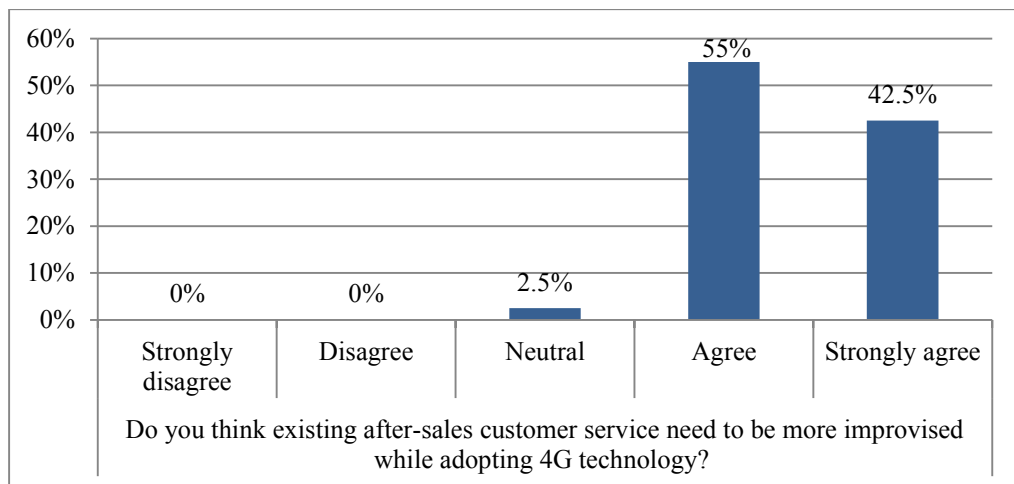


Figure 4:9 Experts' opinion- necessity of improvisation in after-sales customer service

Above figure shows that a large majority of experts (Agree- 55% and Strongly Agree – 42.5%; a total of 97.5%) supported the statement “existing after-sales customer service need to be more improvised while adopting 4G technology”. This may be difficult for operators. However this is a crucial strategy for achieving success.

As 4G technology will be a new technology in Bangladesh, hence customer knowledge-base on this technology is a vital concern. Experts are asked: “Do you think customer knowledge base on 4G technology need to be improved through campaign while adopting this new technology?” Result is shown in Figure 4:10.

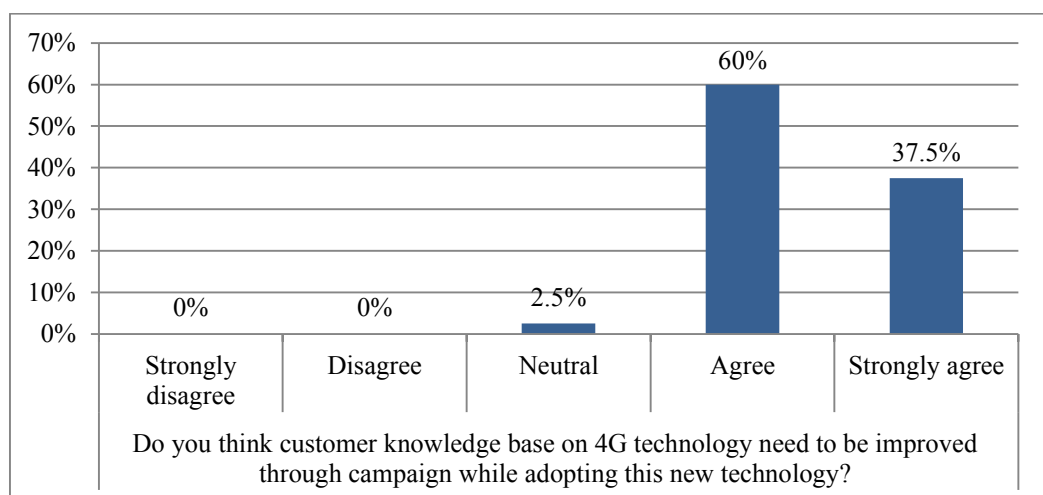


Figure 4:10 Experts' opinion- requirement to improve customer knowledge-base

Figure shows that a large majority of experts (Agree- 60% and Strongly Agree – 37.5%, a total of 97.5%) supported the statement “customer knowledge base on 4G technology need to be improved through campaign while adopting this new technology”. This may be a challenge for operators. However, it is also an important point for strategy formulation.

With introduction of new technology, there will be new type of products (packages) for customers offered by operators. Experts are asked: “Do you think innovative product development is crucial while adopting this new 4G technology?” Result of this question provides experts’ opinion on innovative product for 4G technology business. Result is shown in Figure 4:11.

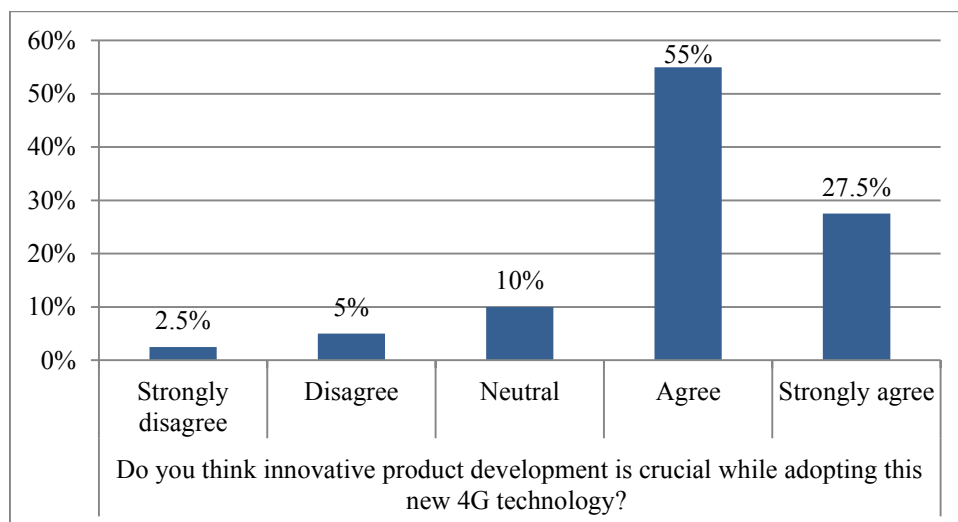


Figure 4:11 Experts’ opinion- necessity of innovative product development

Above figure shows variability in experts’ opinion but majority of experts i.e. 82.5% (Agree- 55% and Strongly Agree – 27.5%) supported the statement “innovative product development is crucial while adopting this new 4G technology”. This is another challenge for operators. However, it is also a critical point for strategy formulation.

Now following section discusses on experts’ opinion on some other strategic points.

4.5 Expert Opinion on Some Other Strategic Points

In this section, experts' opinion on some strategic points are discussed.

As 4G need to be implemented newly in the country, operators must have clear idea on geographical location to focus. Experts are asked: “During initial stage of 4G technology roll-out, which geographical location do you think operators should focus?” Result of this question provides an idea on which geographical area operators should focus during 4G technology launching in Bangladesh and is an important point to formulate the strategy to successfully adopt 4G technology by telecom operators.

Result is shown in Figure 4:12.

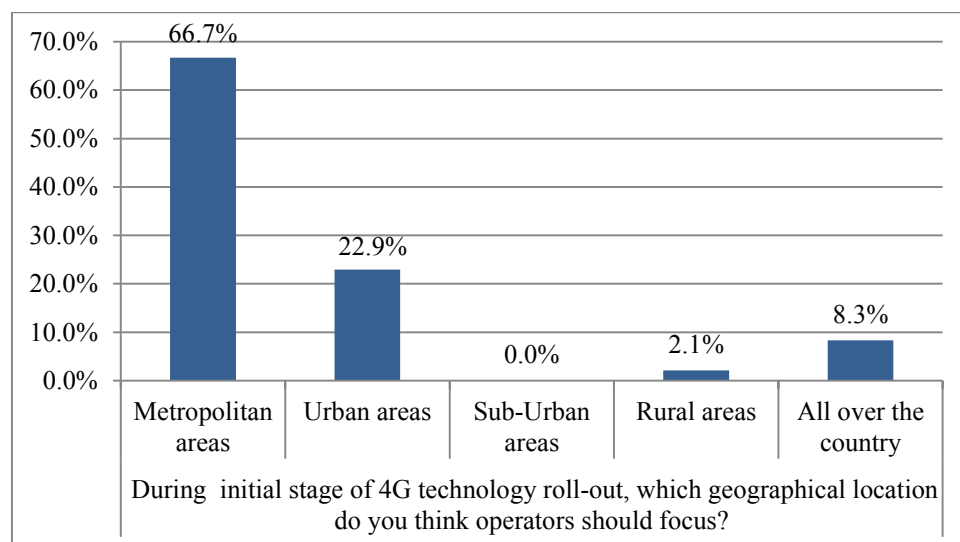


Figure 4:12 Experts' opinion- focus geographical location for operators

Figure shows that majority of experts i.e. 66.7% supported that operators should focus on metropolitan areas during initial stage of 4G technology roll-out i.e. adoption.

Another crucial strategy need to be set that, when 4G technology will be implemented then which technology among 2G, 3G and 4G need to be focused, that means what will be the business continuity approach for operators. Hence, experts are asked: “As 2G and

3G will be running i.e. revenue generating business for operators during 4G roll-out, which of the below should be most appropriate approach for operators?”

Result of this question is provided in Figure 4:13.

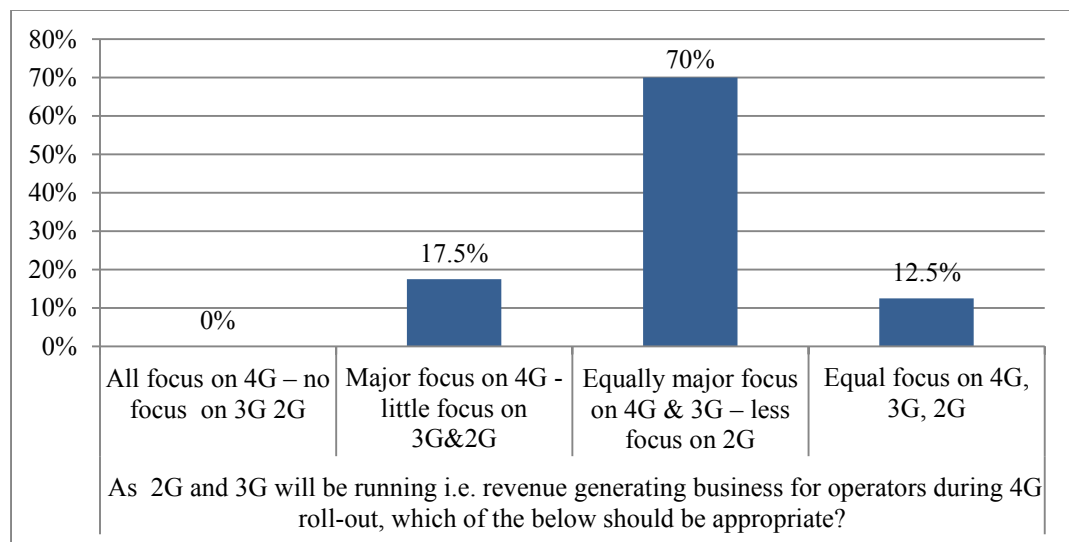


Figure 4:13 Experts’ opinion- focus area for business continuity

Figure shows that majority of the experts (70%) supported that “Operators should equally focus on 4G and 3G and less on 2G” as operators’ business continuity approach during 4G technology adoption. This is a very crucial strategic point for successful adoption of 4G technology as this is related to the core of operators’ business.

Another important point is the market acquisition approach that means what should be the aggressiveness of operators regarding 4G roll-out. Experts are asked: “What will be the most appropriate market acquisition approach for 4G adoption?”

Result of this question is presented in Figure 4:14.

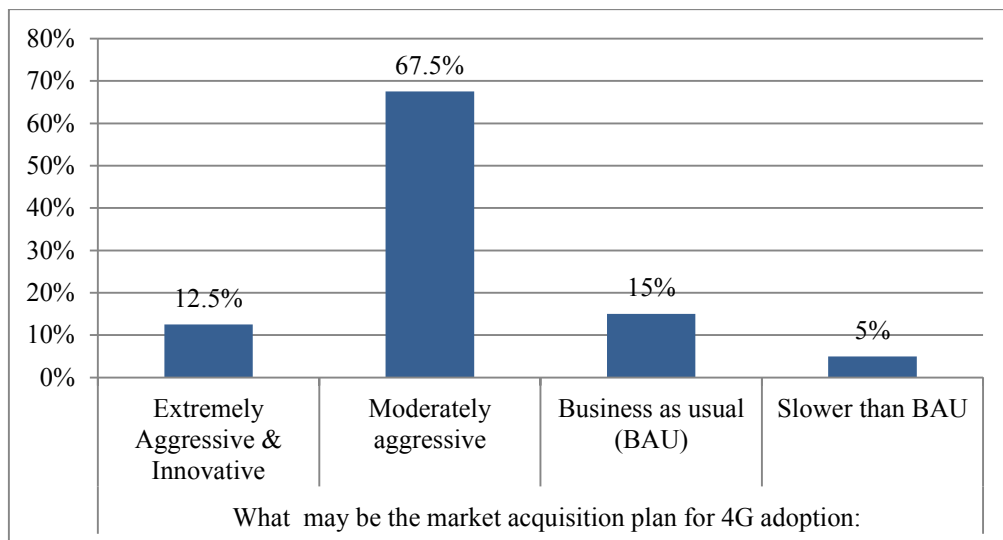


Figure 4:14 Experts' opinion- potential market acquisition approach

Above figure shows that majority of the experts (67.5%) supported that operators should take “Moderately aggressive” market acquisition approach rather than extremely aggressive. But it should not be average (that is business-as-usual).

Finding out focus customer group is very important to finalize strategy for any business and hence it is required to identify potential age-group to be focused for 4G business. Experts are asked: “Which age-group do you think will be major potential customer for 4G technology?” Result of this question is shown in Figure 4:15.

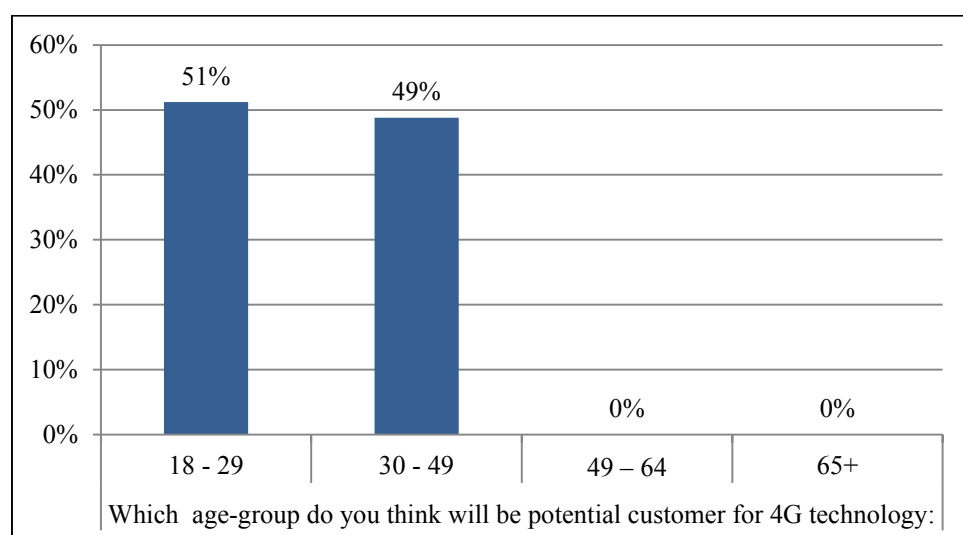


Figure 4:15 Experts' opinion- potential customer age-group

Figure shows that both “18-29” and “30-49” age-groups need to be focused equally as both group are chosen by almost equal number of experts (i.e. 51% choose 18-29 age group and 49% choose 30-49 age group).

Apart from above points, it is also important to find out experts’ opinion on probable negative impacts of growth of telecommunication technology throughout any country. Considering the sensitivity of these questions towards industry, independent experts are asked these two questions. But results of these questions are also reflected in formulating the 4G technology adoption strategy.

Independent experts are asked “Do you think telecom operators need to consider geographical location, congestion of sites, appropriate distance etc. while installing new sites during introduction of this new 4G technology?” Objective of this question is to find out expert opinion on planned installation of telecom sites considering different parameters like geographical location, congestion of sites, appropriate distance etc. Result of this question is shown in Figure 4:16.

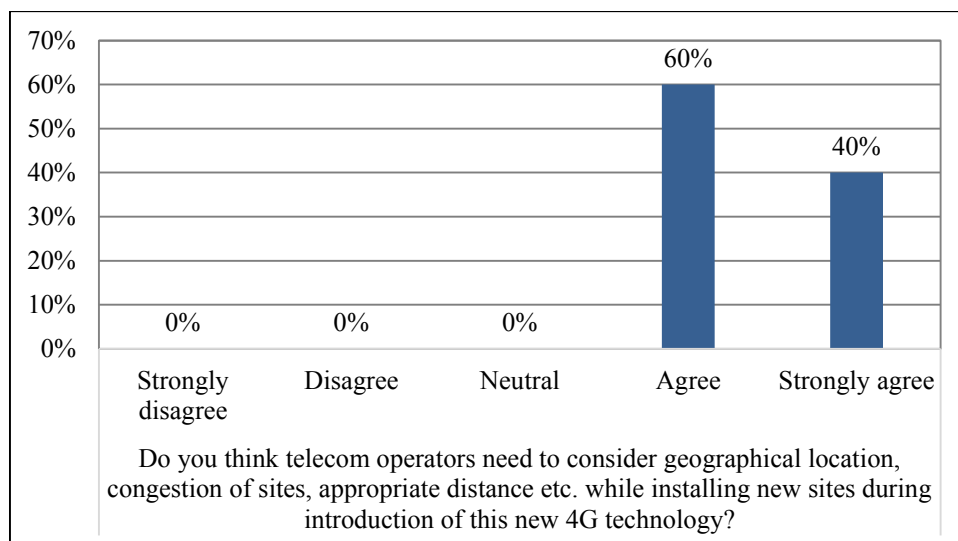


Figure 4:16 Experts’ opinion- planned installation of telecom sites

Figure shows that all the independent experts (Agree- 60%, Strongly agree-40%, in total 100%) supported that telecom operators need to consider geographical location,

congestion of sites, appropriate distance etc. while installing new sites during introduction of 4G technology that means planned installation of telecom sites must be considered.

To find out independent experts' opinion on consideration of environmental and radiation impact of telecom technologies, they are asked "Do you think telecom operators need to consider environmental impact and levels of Electro Magnetic Field (EMF) Radiation from mobile towers while adopting this new 4G technology?" Result of this question is shown in Figure 4:17.

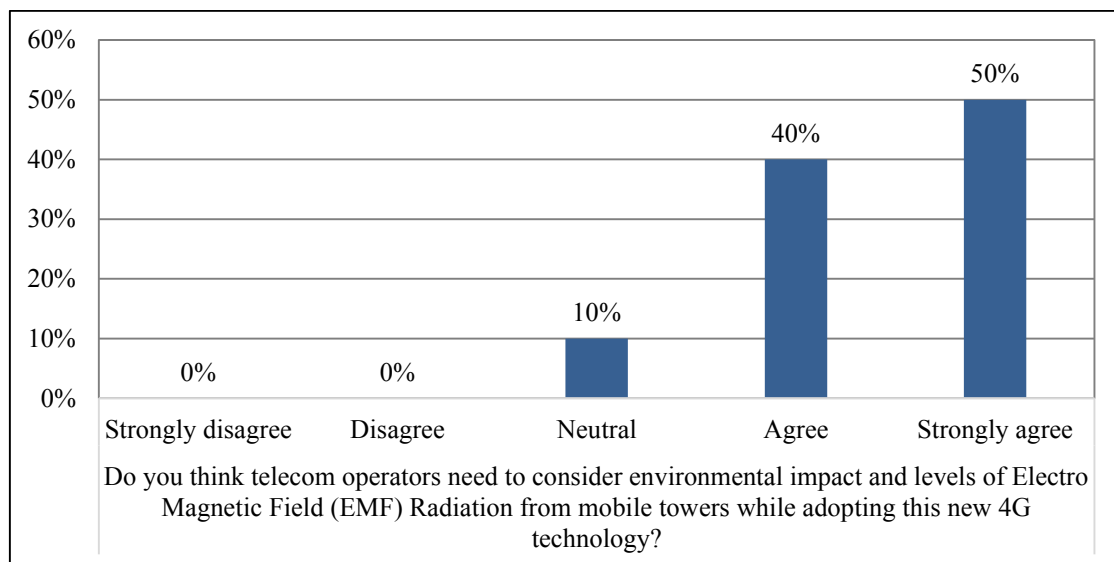


Figure 4:17 Experts' opinion- consideration of environmental and radiation impact of telecom technologies

Figure shows that a large majority of the independent experts (Agree- 40%, Strongly agree-50%, in total 90%) supported that telecom operators need to consider environmental impact and levels of Electro Magnetic Field (EMF) radiation from mobile towers while adopting 4G.

Now in the following sections analysis of experts' opinion on AHP pair-wise comparison matrices is given. At first, analysis of industry experts' opinion is provided in section 4.6, then analysis of independent experts' opinion is provided in section 4.7, then analysis of combined opinion of all experts is provided in section 4.8.

4.6 Analysis of Industry Experts' Opinion on Pair-wise Comparison through AHP

Analysis of expert opinion on pair-wise comparison through AHP is done using the theories and formulae discussed in Section 3.2 with the help of AHP-OS online tool. These data are collected from part 02 of questionnaire. This section (section 4.6) contains industry experts' opinion on pair-wise comparison through AHP and section 4.7 provides the same for independent experts. Section 4.8 provides the consolidation of all experts' (industry and independent) opinion.

4.6.1 AHP analysis: Expert 1

The pair-wise comparison matrix represents the concentrations of the experts' preference between pairs of alternatives. AHP analysis of judgment provided by Expert-1 is initiated by constructing a matrix for criteria's considering Expert-1 feedback which is shown in Table 4-1. Normalized value and priorities of pair-wise comparison are calculated for this matrix using appropriate equations mentioned in Section 3.2 of this thesis.

Table 4-1: Pair-wise comparison matrix (before consistency adjustment) for factors- Expert-1

Pair-wise comparison among factors	F1	F2	F3
Technology (F1)	1	5	5
Sales and Marketing (F2)	1/5	1	4
Ripple effect (F3)	1/5	1/4	1

Normalized values and priorities are presented in Table 4-2.

Table 4-2 : Calculation result (without consistency adjustment) of pair-wise comparison matrix of factors- Expert-1

Factors	Priority score	Remarks
Technology (F1)	0.692776	
Sales and Marketing (F2)	0.219932	
Ripple effect (F3)	0.087292	
Consistency ration (CR)	0.226818	22.68%, Not acceptable. Need consistency adjustment.
Principal Eigen value	3.217	

Calculations from the matrix are derived using AHP-OS. The online views of the tool are presented in following figures. Matrix formed from the pair-wise comparison as opined by Expert-1 is shown in Figure 4:18.

Which criterion with respect to 4G Technology Adoption is more important, and how much more on a scale 1 to 9?

A - Importance - or B?		Equal	How much more?								
1	Technology (F1) or Sales & Marketing (F2)	1	2	3	4	5	6	7	8	9	
2	Technology (F1) or Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	
3	Sales & Marketing (F2) or Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	

Figure 4:18 AHP-OS online view: pair-wise comparison matrix for factors- Expert-1

Calculation result of pair-wise comparison matrix of factors for Expert-1 as found in AHP-OS online tool is shown in Figure 4:19. But this result is obtained before consistency adjustment and it is found that result is not consistent (CR=22.7% which is above acceptance level). In AHP-OS online tool, the most inconsistent decisions are highlighted and the consistent judgments are marked light green. To achieve accepted level of consistency, original decision i.e. priority is adjusted on the AHP scale.

Priorities				Decision Matrix			
These are the resulting weights for the criteria based on your pairwise comparisons				The resulting weights are based on the principal eigenvector of the decision matrix			
Category		Priority	Rank				
1	Technology (F1)	69.3%	1	1	1	5.00	5.00
2	Sales & Marketing (F2)	22.0%	2	2	0.20	1	4.00
3	Ripple Effect (F3)	8.7%	3	3	0.20	0.25	1
Number of comparisons = 3				Principal eigen value = 3.217			
Consistency Ratio CR = 22.7%				Eigenvector solution: 6 iterations, delta = 2.4E-8			

Figure 4:19 AHP-OS online view: result (without consistency adjustment) of pair-wise comparison matrix of factors- Expert-1

The consistent results with modified matrix after consistency adjustment is shown in Figure 4:20.

Which criterion with respect to **4G Technology Adoption** is more important, and how much more on a scale 1 to 9?

A - Importance - or B?		Equal	How much more?
1	☒ Technology (F1) or ☐ Sales & Marketing (F2)	☐ 1	☐ 2 ☐ 3 ☐ 4 ☒ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9
2	☒ Technology (F1) or ☐ Ripple Effect (F3)	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☒ 7 ☐ 8 ☐ 9
3	☐ Sales & Marketing (F2) or ☐ Ripple Effect (F3)	☐ 1	☐ 2 ☐ 3 ☒ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9

CR = 5.6% OK

[Calculate Result](#) ☒ AHP ☐ Balanced scale [Download_\(.csv\)](#) ☐ dec. comma

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons

Category	Priority	Rank
1 Technology (F1)	69.1%	1
2 Sales & Marketing (F2)	21.8%	2
3 Ripple Effect (F3)	9.1%	3

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix

	1	2	3
1	1	4.00	6.00
2	0.25	1	3.00
3	0.17	0.33	1

Number of comparisons = 3
Consistency Ratio CR = 5.6%

Principal eigen value = 3.054
Eigenvector solution: 4 iterations, delta = 1.1E-8

Figure 4:20 AHP-OS online view: result (with consistency adjustment) of pair-wise comparison matrix of factors- Expert-1

Finally pair-wise comparison matrix and calculation with acceptable CR value are derived and these are mentioned in Table 4-3 and Table 4-4.

Table 4-3 Pair-wise comparison matrix (after consistency adjustment) for factors- Expert-1

Pair-wise comparison among factors	F1	F2	F3
Technology (F1)	1	4	6
Sales and Marketing (F2)	1/4	1	3
Ripple effect (F3)	1/6	1/3	1

Table 4-4 Calculation result (with consistency adjustment) of pair-wise comparison matrix of factors- Expert-1

Factors	Priority score	Remarks
Technology (F1)	0.691	
Sales and Marketing (F2)	0.218	
Ripple effect (F3)	0.91	
Consistency ration (CR)	0.056	5.6%, acceptable. Consistency adjusted.
Principal Eigen value	3.054	

Similar pair-wise comparisons and analysis, calculations etc. are done for all the sub-criteria under each criterion. Consistency of the decision i.e. CR value is checked in each case and necessary consistency adjustment is made in appropriate cases. As all these consistency adjustments calculations are of same manners, in all following priority calculations, matrices and calculation tables presented are after consistency adjustment. AHP-OS Online tool view is also same.

Pair-wise comparison matrix and calculation result (after consistency adjustment) for sub-criteria under Technology factor (i.e. Network coverage and quality (F1A1), Technological up-gradation (F1A2), Knowledge development (F1A3)) for Expert-1 are shown in Table 4-5 and Table 4-6. AHP-OS online view is shown in Figure 4:21.

Table 4-5 Pair-wise Comparison matrix (after consistency adjustment) for sub-factors under Technology factor- Expert-1

Pair-wise comparison among sub-factors under Technology factor	F1A1	F1A2	F1A3
Network coverage and quality (F1A1)	1	3	7
Technological up-gradation (F1A2)	1/3	1	3
Knowledge development (F1A3)	1/7	1/3	1

Table 4-6 Calculation result (with consistency adjustment) of pair-wise comparison matrix for sub-factors under Technology factor- Expert-1

Sub-Factors	Priority score	Remarks
Network coverage and quality (F1A1)	0.669416	
Technological up-gradation (F1A2)	0.242637	
Knowledge Development (F1A3)	0.087947	
Consistency ration (CR)	0.007335	0.73%, acceptable. Consistency adjusted.
Principal Eigen value	3.00703	

Which criterion with respect to *Technology (F1)* is more important, and how much more on a scale 1 to 9?

A - Importance - or B?		Equal	How much more?																
1	☒ Network Coverage & quality or ☐ Technological up-gradation	1	☐	2	☐	3	☒	4	☐	5	☐	6	☐	7	☐	8	☐	9	☐
2	☒ Network Coverage & quality or ☐ Knowledge Development	1	☐	2	☐	3	☐	4	☐	5	☒	6	☐	7	☐	8	☐	9	☐
3	☒ Technological up-gradation or ☐ Knowledge Development	1	☐	2	☐	3	☒	4	☐	5	☐	6	☐	7	☐	8	☐	9	☐

CR = 0.7% OK

☒ AHP ☐ Balanced scale ☐ dec. comma

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons

Category	Priority	Rank
1 Network Coverage & quality	66.9%	1
2 Technological up-gradation	24.3%	2
3 Knowledge Development	8.8%	3

Number of comparisons = 3
Consistency Ratio CR = 0.7%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix

	1	2	3
1	1	3.00	7.00
2	0.33	1	3.00
3	0.14	0.33	1

Principal eigen value = 3.007
Eigenvector solution: 3 iterations, delta = 5.1E-9

Figure 4:21 AHP-OS online view: result (with consistency adjustment) of pair-wise comparison matrix of sub-factors under Technology factor- Expert-1

Pair-wise comparison matrix and calculation result (after consistency adjustment) for sub-factors under Sales and Marketing factor [i.e. Advertising and branding (F2B1), Customer classification and analysis (F2B2), Product, packages and pricing (F2B3), After-sales customer service (F2B4)] for Expert-1 are shown in Table 4-7 and

Table 4-8. AHP-OS online view is shown in Figure 4:22.

Table 4-7 Pair-wise comparison matrix (after consistency adjustment) for sub-factors under Sales and Marketing factor- Expert-1

Pair-wise comparison among sub-factors under Sales and Marketing factor	F2B1	F2B2	F2B3	F2B4
Advertising and branding (F2B1)	1	3	1/2	5
Customer classification and analysis (F2B2)	1/3	1	1/2	4
Product, packages and pricing (F2B3)	2	2	1	5
After-sales customer service (F2B4)	1/5	1/4	1/5	1

Table 4-8 Calculation result (with consistency adjustment) of pair-wise comparison matrix for sub-factors under Sales and Marketing factor- Expert-1

Sub-Factors	Priority score	Remarks
Advertising and branding (F2B1)	0.334995	
Customer classification and analysis (F2B2)	0.180162	
Product, packages and pricing (F2B3)	0.422826	
After-sales customer service (F2B4)	0.062018	
Consistency ration (CR)	0.062361	6.24%, acceptable. Consistency adjusted.
Principal Eigen value	4.17014	

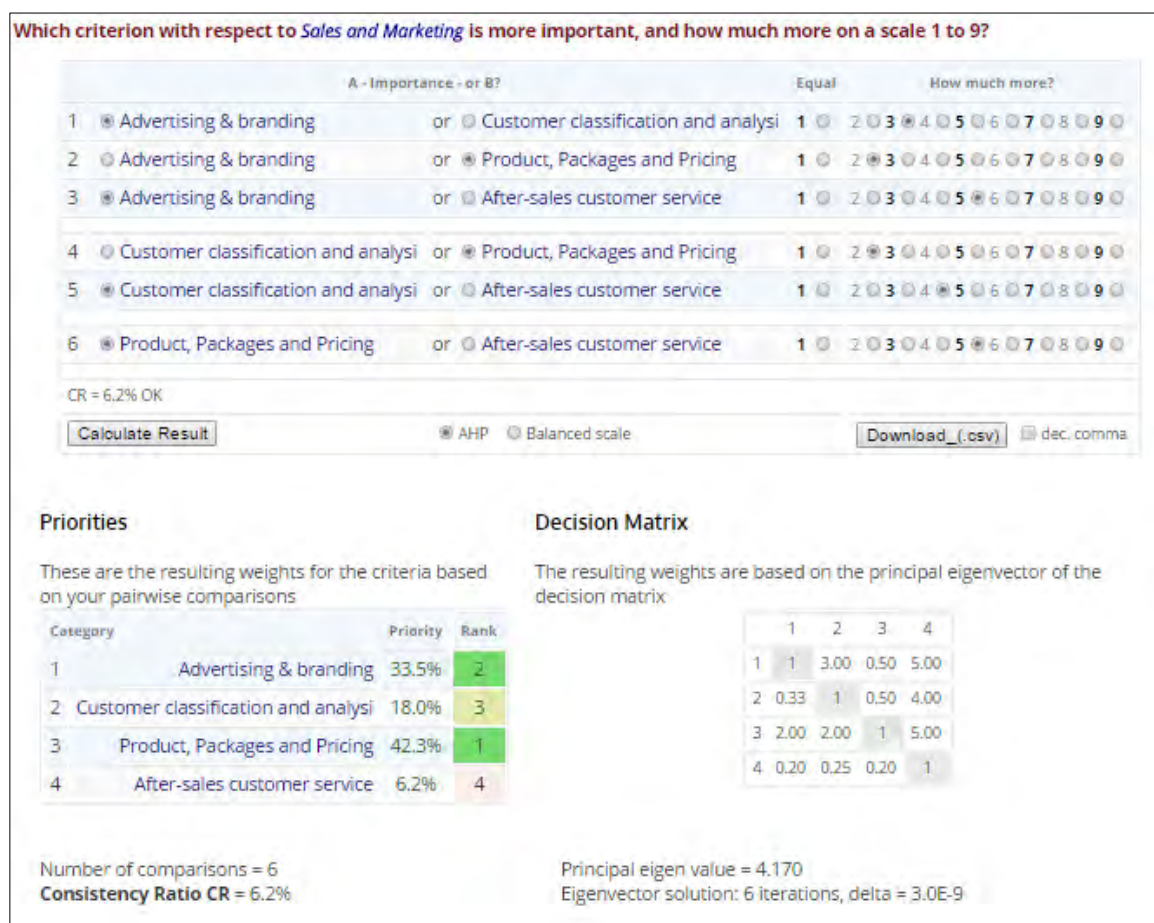


Figure 4:22 AHP-OS online view: result (with consistency adjustment) of pair-wise comparison matrix of sub-factors under Sales and Marketing factor- Expert-1

Pair-wise comparison matrix and calculation result (after consistency adjustment) for sub-factors under Ripple effect factor [i.e. Social Impact, (F3C1), Economic impact (F3C2),

Customer response (F3C3)] for Expert-1 are shown in Table 4-9 and Table 4-10. AHP-OS online view is shown in Figure 4:23.

Table 4-9 Pair-wise comparison matrix (after consistency adjustment) for sub-factors under Ripple Effect factor- Expert-1

Pair-wise comparison among sub-factors under Ripple effect factor	F3C1	F3C2	F3C3
Social impact, (F3C1)	1	1/7	1/3
Economic impact (F3C2)	7	1	3
Customer response (F3C3)	3	1/3	1

Table 4-10 Calculation result (with consistency adjustment) of pair-wise comparison matrix for sub-factors under Ripple effect factor- Expert-1

Sub-Factors	Priority score	Remarks
Social impact, (F3C1)	8.79%	
Economic impact (F3C2)	66.94%	
Customer response (F3C3)	24.26%	
Consistency ration (CR)	0.73%	Acceptable. Consistency adjusted.
Principal Eigen value	3.00703	



Figure 4:23 AHP-OS online view: result (with consistency adjustment) of pair-wise comparison matrix of sub-factors under Ripple Effect factor- Expert-1

After that, formation of pair-wise comparison matrix and result calculation result with consistency adjustment are done for alternatives [i.e. Voice service, Data service, Value Added Services (VAS)] with respect to all 10 sub-factors.

Comparison matrix and calculation result for alternatives with respect to sub-factors Network coverage and quality (F1A1) are shown in Table 4-11 and

Table 4-12. An AHP-OS online view for this is presented in Figure 4:24.

Table 4-11 Pair-wise comparison matrix (after consistency adjustment) for alternatives with respect to sub-factor Network coverage and quality (F1A1)- Expert-1

Pair-wise comparison among alternatives	S1	S2	S3
Voice service (S1)	1	1/3	3
Data Service (S2)	3	1	7
Value Added Services (VAS) (S3)	1/3	1/7	1

Table 4-12 Calculation result (with consistency adjustment) of pair-wise comparison matrix for alternatives with respect to sub-factor Network coverage and quality (F1A1)- Expert-1

Alternatives	Priority score	Remarks
Voice service (S1)	24.3%	
Data Service (S2)	66.9%	
Value Added Services (VAS) (S3)	8.8%	
Consistency ration (CR)	0.73%	Acceptable. Consistency adjusted.
Principal Eigen value	3.00703	



Figure 4:24 AHP-OS online view: result (with consistency adjustment) of pair-wise comparison matrix for alternatives with respect to sub-factor Network coverage and quality (F1A1): Expert-1

Similar pair-wise comparison matrix formation and result calculation are done for alternatives with respect to all other 9 sub-factors [i.e. Technological up-gradation (F1A2), Knowledge development (F1A3), Advertising and branding (F2B1), Customer classification and analysis (F2B2), Product, packages and pricing (F2B3), After-sales customer service (F2B4), Social impact (F3C1), Economic impact (F3C2), Customer response (F3C3)]. These are not presented here in details as the matrix formation and calculations are same as above. But priority score for these are considered for the final calculation.

Final result i.e. local and global priorities for all applicable cases are calculated from the formulae mentioned in section 3.2 using AHP-OS online tool. AHP-OS online view of calculation result (with consistency adjustment) – priorities for factors, sub-factors and alternatives are shown in Figure 4:25.

Decision Hierarchy							
Level 0	Level 1	Level 2	Global Priorities	Voice	Data	VAS	
Strategy	Technology0.691	Network Coverage & quality0.6694	46.3 %	0.1122	0.3096	0.0407	
		Technological up-gradation0.2426	16.8 %	0.0407	0.1122	0.0147	
		Knowledge Development0.0879	6.1 %	0.0147	0.0407	0.0053	
	Sales & Marketing0.2176	Advertising & branding0.335	7.3 %	0.0177	0.0488	0.0064	
		Customer classification & analysis0.1802	3.9 %	0.0095	0.0262	0.0034	
		Product-Packages & Pricing0.4228	9.2 %	0.0223	0.0616	0.0081	
		After-sales customer service0.062	1.3 %	0.0033	0.009	0.0012	
	Ripple effect0.0914	Social impact0.0879	0.8 %	0.002	0.0054	0.0007	
		Economic impact0.6694	6.1 %	0.0148	0.041	0.0054	
		Customer response0.2426	2.2 %	0.0054	0.0148	0.002	
OK. Submit for group eval or alternative eval. Alternatives			1.0	24.3 %	66.9 %	8.8 %	

Figure 4:25 AHP-OS online view of calculation result (with consistency adjustment) – priorities for factors, sub-factors and alternatives- Expert-1

Final calculation results for Expert-1 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for criteria (under expert-1 judgment analysis) are presented in Table 4-13.

Table 4-13 Global priorities and global weights for factors – Expert-1 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6910	69.10%
Sales and Marketing	0.2176	21.76%
Ripple effect	0.0914	9.14%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under expert-1 judgment analysis) are presented in Table 4-14.

Table 4-14 Global priorities and global weights for sub--factors – Expert-1 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4625	46.25%
Technological up-gradation	0.1677	16.77%
Knowledge development	0.0608	6.08%
Advertising and branding	0.0729	7.29%
Customer classification and analysis	0.0392	3.92%
Product-packages and pricing	0.0920	9.20%
After-sales customer service	0.0135	1.35%
Social impact	0.0080	0.80%
Economic impact	0.0612	6.12%
Customer response	0.0222	2.22%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-1 judgment analysis) are presented in Table 4-15.

Table 4-15 Global priorities and global weights for alternatives – Expert-1 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2426	24.26%
Data	0.6694	66.94%
VAS	0.0879	8.79%
Total	1.0000	100.00%

From above table, it is found that for 4G technology adoption strategy formulation, Expert-1 preferred Technology factor as the most important factor and Network coverage and quality as the most important sub-factor. Tables show that Expert-1 preferred Data service most than all other alternatives with 66.94% global weight followed by Voice service and VAS.

4.6.2 AHP analysis: Expert 2

Similar AHP analysis is done for Expert-2 judgment. Final result i.e. local and global priorities for all applicable cases are calculated from the formulae using AHP-OS online tool. AHP-OS online view of calculation result (with consistency adjustment) – priorities for factors, sub-factors and alternatives are shown in Figure 4:26.

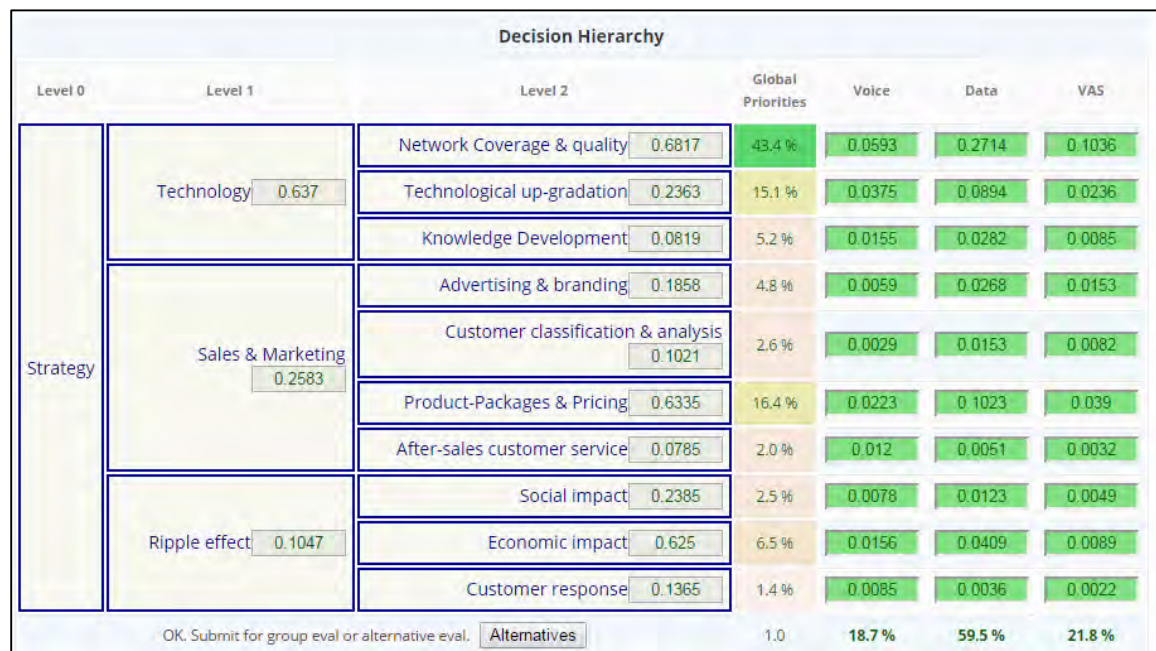


Figure 4:26 AHP-OS online view of calculation result (with consistency adjustment) – priorities for factors, sub-factors and alternatives: Expert-2

Final calculation result for Expert-2 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-2 judgment analysis) are presented in Table 4-16.

Table 4-16 Global priorities and global weights for factors – Expert-2 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6370	63.70%
Sales and Marketing	0.2583	25.83%
Ripple effect	0.1047	10.47%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-2 judgment analysis) are presented in Table 4-17.

Table 4-17 Global priorities and global weights for sub-factors – Expert-2 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4342	43.42%
Technological up-gradation	0.1505	15.05%
Knowledge development	0.0522	5.22%
Advertising and branding	0.0480	4.80%
Customer classification and analysis	0.0264	2.64%
Product-packages and pricing	0.1636	16.36%
After-sales customer service	0.0203	2.03%
Social impact	0.0201	2.01%
Economic impact	0.0664	6.64%
Customer response	0.0183	1.83%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-2 judgment analysis) are presented in

Table 4-18.

Table 4-18 Global priorities and global weights for alternatives – Expert-2 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1883	18.83%
Data	0.5944	59.44%
VAS	0.2173	21.73%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-2 preferred Technology factor as the most important factor and Network coverage and quality as the most important sub-factor. Tables show that Expert-2 preferred Data service most than all other alternatives with 59.54% global weight followed by Voice service and VAS.

Similar AHP analyses are done for all other experts (i.e. from Expert-3 to Expert-30) for all applicable cases using AHP-OS online tool. These AHP-OS online view of calculation results are not presented here in details as these views are same as above. Only the data are presented in tables.

4.6.3 AHP analysis: Expert 3

Final calculation result for Expert-3 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-3 judgment analysis) are presented in Table 4-19.

Table 4-19 Global priorities and global weights for factors –Expert-3 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.4000	40.00%
Sales and Marketing	0.4000	40.00%
Ripple effect	0.2000	20.00%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-3 judgment analysis) are presented in Table 4-20.

Table 4-20 Global priorities and global weights for sub-factors –Expert-3 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1600	16.00%
Technological up-gradation	0.1600	16.00%
Knowledge development	0.0800	8.00%
Advertising and branding	0.1105	11.05%
Customer classification and analysis	0.0781	7.81%
Product-packages and pricing	0.1562	15.62%
After-sales customer service	0.0552	5.52%
Social impact	0.0622	6.22%
Economic impact	0.0987	9.87%
Customer response	0.0392	3.92%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-3 judgment analysis) are presented in Table 4-21.

Table 4-21 Global priorities and global weights for alternatives –Expert-3 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2368	23.68%
Data	0.5371	53.71%
VAS	0.2261	22.61%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-3 equally preferred Technology and Sales and Marketing factors as the most important factor(s). In case of sub-factors also, Expert-3 equally preferred two sub-factors as most important which are Network coverage and quality and Technological up-gradation. Tables show that Expert-3 preferred Data service most than all other alternatives with 53.71% global weight followed by Voice service and VAS.

4.6.4 AHP analysis: Expert 4

Final calculation result for Expert-4 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-4 judgment analysis) are presented in Table 4-22.

Table 4-22 Global priorities and global weights for factors –Expert-4 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6370	63.70%
Sales and Marketing	0.2583	25.83%
Ripple effect	0.1047	10.47%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-4 judgment analysis) are presented in Table 4-23.

Table 4-23 Global priorities and global weights for sub-factors –Expert-4 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2548	25.48%
Technological up-gradation	0.2548	25.48%
Knowledge development	0.1274	12.74%
Advertising and branding	0.0334	3.34%
Customer classification and analysis	0.1448	14.48%
Product-packages and pricing	0.0630	6.30%
After-sales customer service	0.0172	1.72%
Social impact	0.0100	1.00%
Economic impact	0.0686	6.86%
Customer response	0.0262	2.62%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-4 judgment analysis) are presented in Table 4-24.

Table 4-24 Global priorities and global weights for alternatives –Expert-4 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.4643	46.43%
Data	0.3780	37.80%
VAS	0.1577	15.77%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-4 preferred Technology as the most important factor(s). In case of sub-factors, Expert-4 equally preferred two sub-factors as most important which are Network coverage and quality and Technological up-gradation. Tables show that Expert-4 preferred Voice service most than all other alternatives with 46.43% global weight followed by Data service and VAS.

4.6.5 AHP analysis: Expert 5

Final calculation result for Expert-5 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in below tables and graphs. Global

priorities and global weights for factors (under Expert-5 judgment analysis) are presented in Table 4-25.

Table 4-25 Global priorities and global weights for factors –Expert-5 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.4126	41.26%
Sales and Marketing	0.3275	32.75%
Ripple effect	0.2599	25.99%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-5 judgment analysis) are presented in Table 4-26.

Table 4-26 Global priorities and global weights for sub-factors –Expert-5 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1768	17.68%
Technological up-gradation	0.1768	17.68%
Knowledge development	0.0589	5.89%
Advertising and branding	0.0819	8.19%
Customer classification and analysis	0.0819	8.19%
Product-packages and pricing	0.0819	8.19%
After-sales customer service	0.0819	8.19%
Social impact	0.0520	5.20%
Economic impact	0.0520	5.20%
Customer response	0.1560	15.60%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-4 judgment analysis) are presented in Table 4-27.

Table 4-27 Global priorities and global weights for alternatives –Expert-5 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2240	22.40%
Data	0.4792	47.92%
VAS	0.2968	29.68%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-5 preferred Technology as the most important factor(s). In case of sub-factors, Expert-5 equally preferred Network coverage and quality and Technological up-gradation as most important. Tables show that Expert-5 preferred Data service most than all other alternatives with 47.92% global weight followed by VAS and Voice Service.

4.6.6 AHP analysis: Expert 6

Final calculation result for Expert-6 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-6 judgment analysis) are presented in Table 4-28.

Table 4-28 Global priorities and global weights for factors –Expert-6 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.4434	44.34%
Sales and Marketing	0.3874	38.74%
Ripple effect	0.1692	16.92%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-6 judgment analysis) are presented in Table 4-29.

Table 4-29 Global priorities and global weights for sub-factors –Expert-6 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1774	17.74%
Technological up-gradation	0.1774	17.74%
Knowledge development	0.0887	8.87%
Advertising and branding	0.1743	17.43%
Customer classification and analysis	0.1052	10.52%
Product-packages and pricing	0.0742	7.42%
After-sales customer service	0.0337	3.37%
Social impact	0.0286	2.86%
Economic impact	0.0750	7.50%
Customer response	0.0655	6.55%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-6 judgment analysis) are presented in Table 4-30.

Table 4-30 Global priorities and global weights for alternatives –Expert-6 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.3964	39.64%
Data	0.3981	39.81%
VAS	0.2056	20.56%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-6 preferred Technology as the most important factor(s). In case of sub-factors, Expert-6 equally preferred two sub-factors as most important which are Network coverage and quality and Technological up-gradation. Tables show that Expert-6 preferred Data service most than all other alternatives with 39.81% global weight followed by Voice Service and VAS.

4.6.7 AHP analysis: Expert 7

Final calculation result for Expert-7 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in below tables.

Global priorities and global weights for factors (under Expert-7 judgment analysis) are presented in Table 4-31.

Table 4-31 Global priorities and global weights for factors –Expert-7 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-7 judgment analysis) are presented in Table 4-32.

Table 4-32 Global priorities and global weights for sub-factors –Expert-7 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1593	15.93%
Technological up-gradation	0.3647	36.47%
Knowledge development	0.0696	6.96%
Advertising and branding	0.0671	6.71%
Customer classification and analysis	0.1316	13.16%
Product-packages and pricing	0.0355	3.55%
After-sales customer service	0.0151	1.51%
Social impact	0.0257	2.57%
Economic impact	0.0847	8.47%
Customer response	0.0466	4.66%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-7 judgment analysis) are presented in Table 4-33.

Table 4-33 Global priorities and global weights for alternatives –Expert-7 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2874	28.74%
Data	0.5592	55.92%
VAS	0.1534	15.34%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-7 preferred Technology as the most important factor(s). In case of sub-factors, Expert-7 preferred Technological up-gradation as most important sub-factor. Tables show that Expert-7 preferred Data service most than all other alternatives with 55.92% global weight followed by Voice Service and VAS.

4.6.8 AHP analysis: Expert 8

Final calculation result for Expert-8 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-8 judgment analysis) are presented in Table 4-34.

Table 4-34 Global priorities and global weights for factors –Expert-8 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.4934	49.34%
Sales and Marketing	0.3108	31.08%
Ripple effect	0.1958	19.58%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-8 judgment analysis) are presented in Table 4-35.

Table 4-35 Global priorities and global weights for sub-factors –Expert-8 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1130	11.30%
Technological up-gradation	0.3431	34.31%
Knowledge development	0.0372	3.72%
Advertising and branding	0.0553	5.53%
Customer classification and analysis	0.0725	7.25%
Product-packages and pricing	0.1622	16.22%
After-sales customer service	0.0208	2.08%
Social impact	0.0489	4.89%
Economic impact	0.0979	9.79%
Customer response	0.0489	4.89%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-8 judgment analysis) are presented in Table 4-36.

Table 4-36 Global priorities and global weights for alternatives –Expert-8 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.3959	39.59%
Data	0.4614	46.14%
VAS	0.1427	14.27%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-8 preferred Technology as the most important factor(s). In case of sub-factors, Expert-8 preferred Technological up-gradation as most important sub-factor. Tables show

that Expert-8 preferred Data service most than all other alternatives with 46.14% global weight followed by Voice Service and VAS.

4.6.9 AHP analysis: Expert 9

Final calculation result for Expert-9 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-9 judgment analysis) are presented in Table 4-37.

Table 4-37 Global priorities and global weights for factors –Expert-9 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6608	66.08%
Sales and Marketing	0.2081	20.81%
Ripple effect	0.1311	13.11%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-9 judgment analysis) are presented in Table 4-38.

Table 4-38 Global priorities and global weights for sub-factors –Expert-9 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4060	40.60%
Technological up-gradation	0.1773	17.73%
Knowledge development	0.0775	7.75%
Advertising and branding	0.1039	10.39%
Customer classification and analysis	0.0250	2.50%
Product-packages and pricing	0.0651	6.51%
After-sales customer service	0.0141	1.41%
Social impact	0.0896	8.96%
Economic impact	0.0262	2.62%
Customer response	0.0153	1.53%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-9 judgment analysis) are presented in Table 4-39.

Table 4-39 Global priorities and global weights for alternatives –Expert-9 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.4071	40.71%
Data	0.4612	46.12%
VAS	0.1318	13.18%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-9 preferred Technology as the most important factor(s). In case of sub-factors, Expert-9 preferred Network coverage and quality as most important sub-factor. Tables show that Expert-9 preferred Data service most than all other alternatives with 46.12% global weight followed by Voice Service and VAS.

4.6.10 AHP analysis: Expert 10

Final calculation result for Expert-10 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-10 judgment analysis) are presented in Table 4-40.

Table 4-40 Global priorities and global weights for factors –Expert-10 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.7171	71.71%
Sales and Marketing	0.2172	21.72%
Ripple effect	0.0658	6.58%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-10 judgment analysis) are presented in Table 4-41.

Table 4-41 Global priorities and global weights for sub-factors –Expert-10 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1390	13.90%
Technological up-gradation	0.5327	53.27%
Knowledge development	0.0454	4.54%
Advertising and branding	0.1454	14.54%
Customer classification and analysis	0.0120	1.20%
Product-packages and pricing	0.0477	4.77%
After-sales customer service	0.0120	1.20%
Social impact	0.0120	1.20%
Economic impact	0.0488	4.88%
Customer response	0.0049	0.49%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-10 judgment analysis) are presented in Table 4-42.

Table 4-42 Global priorities and global weights for alternatives –Expert-10 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.5297	52.97%
Data	0.3704	37.04%
VAS	0.0999	9.99%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-10 preferred Technology as the most important factor(s). In case of sub-factors, Expert-10 preferred Technological up-gradation as most important sub-factor. Tables show that Expert-10 preferred Voice service most than all other alternatives with 52.97% global weight followed by Data and VAS.

4.6.11 AHP analysis: Expert 11

Final calculation result for Expert-11 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-11 judgment analysis) are presented in Table 4-43.

Table 4-43 Global priorities and global weights for factors –Expert-11 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6667	66.67%
Sales and Marketing	0.2222	22.22%
Ripple effect	0.1111	11.11%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-11 judgment analysis) are presented in Table 4-44.

Table 4-44 Global priorities and global weights for sub-factors –Expert-11 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2963	29.63%
Technological up-gradation	0.2963	29.63%
Knowledge development	0.0741	7.41%
Advertising and branding	0.0287	2.87%
Customer classification and analysis	0.1270	12.70%
Product-packages and pricing	0.0498	4.98%
After-sales customer service	0.0167	1.67%
Social impact	0.0140	1.40%
Economic impact	0.0462	4.62%
Customer response	0.0509	5.09%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-11 judgment analysis) are presented in Table 4-45.

Table 4-45 Global priorities and global weights for alternatives –Expert-11 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1233	12.33%
Data	0.6732	67.32%
VAS	0.2036	20.36%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-11 preferred Technology as the most important factor(s). In case of sub-factors,

Expert-6 equally preferred two sub-factors as most important which are Network coverage and quality and Technological up-gradation. Tables show that Expert-11 preferred Data service most than all other alternatives with 67.32% global weight followed by VAS and Voice Service.

4.6.12 AHP analysis: Expert 12

Final calculation result for Expert-12 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-12 judgment analysis) are presented in Table 4-46.

Table 4-46 Global priorities and global weights for factors –Expert-12 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-12 judgment analysis) are presented in Table 4-47.

Table 4-47 Global priorities and global weights for sub-factors –Expert-12 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3647	36.47%
Technological up-gradation	0.1593	15.93%
Knowledge development	0.0696	6.96%
Advertising and branding	0.0563	5.63%
Customer classification and analysis	0.0284	2.84%
Product-packages and pricing	0.1511	15.11%
After-sales customer service	0.0135	1.35%
Social impact	0.0392	3.92%
Economic impact	0.0932	9.32%
Customer response	0.0247	2.47%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-12 judgment analysis) are presented in Table 4-48.

Table 4-48 Global priorities and global weights for alternatives –Expert-12 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2118	21.18%
Data	0.5668	56.68%
VAS	0.2214	22.14%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-12 preferred Technology as the most important factor(s). In case of sub-factors, Expert-12 preferred Network coverage and quality as most important. Tables show that Expert-12 preferred Data service most than all other alternatives with 56.68% global weight followed by VAS and Voice Service.

4.6.13 AHP analysis: Expert 13

Final calculation result for Expert-13 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-13 judgment analysis) are presented in Table 4-49.

Table 4-49 Global pPriorities and global weights for factors –Expert-13 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5278	52.78%
Sales and Marketing	0.3325	33.25%
Ripple effect	0.1396	13.96%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-13 judgment analysis) are presented in Table 4-50.

Table 4-50 Global priorities and global weights for sub-factors –Expert-13 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3308	33.08%
Technological up-gradation	0.1476	14.76%
Knowledge development	0.0494	4.94%
Advertising and branding	0.0957	9.57%
Customer classification and analysis	0.0562	5.62%
Product-packages and pricing	0.1125	11.25%
After-sales customer service	0.0680	6.80%
Social impact	0.0304	3.04%
Economic impact	0.0965	9.65%
Customer response	0.0128	1.28%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-13 judgment analysis) are presented in Table 4-51.

Table 4-51 Global priorities and global weights for alternatives –Expert-13 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2300	23.00%
Data	0.6051	60.51%
VAS	0.1649	16.49%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-13 preferred Technology as the most important factor(s). In case of sub-factors, Expert-13 preferred Network coverage and quality as most important. Tables show that Expert-13 preferred Data service most than all other alternatives with 60.51% global weight followed by Voice Service and VAS.

4.6.14 AHP analysis: Expert 14

Final calculation result for Expert-14 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-14 judgment analysis) are presented in Table 4-52.

Table 4-52 Global priorities and global weights for factors –Expert-14 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5499	54.99%
Sales and Marketing	0.2402	24.02%
Ripple effect	0.2098	20.98%
Total	1.0000	100.00%

Global priorities and global weights for Sub-factors (under Expert-14 judgment analysis) are presented in Table 4-53.

Table 4-53 Global priorities and global weights for sub-factors –Expert-14 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2903	29.03%
Technological up-gradation	0.1829	18.29%
Knowledge development	0.0768	7.68%
Advertising and branding	0.0654	6.54%
Customer classification and analysis	0.0334	3.34%
Product-packages and pricing	0.1280	12.80%
After-sales customer service	0.0133	1.33%
Social impact	0.0192	1.92%
Economic impact	0.1450	14.50%
Customer response	0.0457	4.57%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-14 judgment analysis) are presented in Table 4-54.

Table 4-54 Global priorities and global weights for alternatives –Expert-14 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2265	22.65%
Data	0.7111	71.11%
VAS	0.0623	6.23%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-14 preferred Technology as the most important factor(s). In case of sub-factors, Expert-14 preferred Network coverage and quality as most important. Tables show that Expert-14 preferred Data service most than all other alternatives with 71.11% global weight followed by Voice Service and VAS.

4.6.15 AHP analysis: Expert 15

Final calculation result for Expert-15 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-15 judgment analysis) are presented in Table 4-55.

Table 4-55 Global priorities and global weights for factors –Expert-15 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6910	69.10%
Sales and Marketing	0.2176	21.76%
Ripple effect	0.0914	9.14%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-15 judgment analysis) are presented in Table 4-56.

Table 4-56 Global priorities and global weights for sub-factors –Expert-15 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4806	48.06%
Technological up-gradation	0.1583	15.83%
Knowledge development	0.0521	5.21%
Advertising and branding	0.0662	6.62%
Customer classification and analysis	0.0309	3.09%
Product-packages and pricing	0.1088	10.88%
After-sales customer service	0.0117	1.17%
Social impact	0.0284	2.84%
Economic impact	0.0451	4.51%
Customer response	0.0179	1.79%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-15 judgment analysis) are presented in Table 4-57.

Table 4-57 Global priorities and global weights for alternatives –Expert-15 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2212	22.12%
Data	0.5592	55.92%
VAS	0.2196	21.96%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-15 preferred Technology as the most important factor(s). In case of sub-factors, Expert-15 preferred Network coverage and quality as most important. Tables show that Expert-15 preferred Data service most than all other alternatives with 55.92% global weight followed by Voice Service and VAS.

4.6.16 AHP analysis: Expert 16

Final calculation result for Expert-16 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-16 judgment analysis) are presented in Table 4-58.

Table 4-58 Global priorities and global weights for factors –Expert-16 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5396	53.96%
Sales and Marketing	0.2970	29.70%
Ripple effect	0.1634	16.34%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-16 judgment analysis) are presented in Table 4-59.

Table 4-59 Global priorities and global weights for sub-factors –Expert-16 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2912	29.12%
Technological up-gradation	0.1602	16.02%
Knowledge development	0.0882	8.82%
Advertising and branding	0.1459	14.59%
Customer classification and analysis	0.0278	2.78%
Product-packages and pricing	0.0798	7.98%
After-sales customer service	0.0434	4.34%
Social impact	0.0228	2.28%
Economic impact	0.0863	8.63%
Customer response	0.0543	5.43%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-16 judgment analysis) are presented in Table 4-60.

Table 4-60 Global priorities and global weights for alternatives –Expert-16 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.3856	38.56%
Data	0.4531	45.31%
VAS	0.1614	16.14%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-16 preferred Technology as the most important factor(s). In case of sub-factors, Expert-16 preferred Network coverage and quality as most important. Tables show that Expert-16 preferred Data service most than all other alternatives with 45.31% global weight followed by Voice Service and VAS.

4.6.17 AHP analysis: Expert 17

Final calculation result for Expert-17 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-17 judgment analysis) are presented in Table 4-61.

Table 4-61 Global priorities and global weights for factors –Expert-17 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6442	64.42%
Sales and Marketing	0.2706	27.06%
Ripple effect	0.0852	8.52%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-17 judgment analysis) are presented in Table 4-62.

Table 4-62 Global priorities and global weights for sub-factors –Expert-17 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4620	46.20%
Technological up-gradation	0.1254	12.54%
Knowledge development	0.0567	5.67%
Advertising and branding	0.0738	7.38%
Customer classification and analysis	0.0371	3.71%
Product-packages and pricing	0.1393	13.93%
After-sales customer service	0.0203	2.03%
Social impact	0.0089	0.89%
Economic impact	0.0543	5.43%
Customer response	0.0220	2.20%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-17 judgment analysis) are presented in Table 4-63.

Table 4-63 Global priorities and global weights for alternatives –Expert-17 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2385	23.85%
Data	0.6509	65.09%
VAS	0.1106	11.06%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-17 preferred Technology as the most important factor(s). In case of sub-factors, Expert-17 preferred Network coverage and quality as most important. Tables show that Expert-17 preferred Data service most than all other alternatives with 65.09% global weight followed by Voice Service and VAS.

4.6.18 AHP analysis: Expert 18

Final calculation result for Expert-18 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-18 judgment analysis) are presented in Table 4-64.

Table 4-64 Global priorities and global weights for factors –Expert-18 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-18 judgment analysis) are presented in Table 4-65.

Table 4-65 Global priorities and global weights for sub-factors –Expert-18 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3524	35.24%
Technological up-gradation	0.1480	14.80%
Knowledge development	0.0932	9.32%
Advertising and branding	0.0690	6.90%
Customer classification and analysis	0.0427	4.27%
Product-packages and pricing	0.1189	11.89%
After-sales customer service	0.0188	1.88%
Social impact	0.0392	3.92%
Economic impact	0.0932	9.32%
Customer response	0.0247	2.47%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-18 judgment analysis) are presented in Table 4-66.

Table 4-66 Global priorities and global weights for alternatives –Expert-18 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2216	22.16%
Data	0.5737	57.37%
VAS	0.2048	20.48%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-18 preferred Technology as the most important factor(s). In case of sub-factors, Expert-18 preferred Network coverage and quality as most important. Tables show that Expert-18 preferred Data service most than all other alternatives with 57.37% global weight followed by Voice Service and VAS.

4.6.19 AHP analysis: Expert 19

Final calculation result for Expert-19 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-19 judgment analysis) are presented in Table 4-67.

Table 4-67 Global priorities and global weights for factors –Expert-19 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5278	52.78%
Sales and Marketing	0.3325	33.25%
Ripple effect	0.1396	13.96%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-19 judgment analysis) are presented in Table 4-68.

Table 4-68 Global priorities and global weights for sub-factors –Expert-19 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3133	31.33%
Technological up-gradation	0.1316	13.16%
Knowledge development	0.0829	8.29%
Advertising and branding	0.0749	7.49%
Customer classification and analysis	0.0592	5.92%
Product-packages and pricing	0.1670	16.70%
After-sales customer service	0.0313	3.13%
Social impact	0.0335	3.35%
Economic impact	0.0768	7.68%
Customer response	0.0293	2.93%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-19 judgment analysis) are presented in Table 4-69.

Table 4-69 Global priorities and global weights for alternatives –Expert-19 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2765	27.65%
Data	0.4540	45.40%
VAS	0.2694	26.94%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-19 preferred Technology as the most important factor(s). In case of sub-factors, Expert-19 preferred Network coverage and quality as most important. Tables show that Expert-19 preferred Data service most than all other alternatives with 57.37% global weight followed by Voice Service and VAS.

4.6.20 AHP analysis: Expert 20

Final calculation result for Expert-20 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-20 judgment analysis) are presented in Table 4-70.

Table 4-70 Global priorities and global weights for factors –Expert-20 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6144	61.44%
Sales and Marketing	0.2684	26.84%
Ripple effect	0.1172	11.72%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-20 judgment analysis) are presented in Table 4-71.

Table 4-71 Global priorities and global weights for sub-factors –Expert-20 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1649	16.49%
Technological up-gradation	0.3775	37.75%
Knowledge development	0.0720	7.20%
Advertising and branding	0.1451	14.51%
Customer classification and analysis	0.0353	3.53%
Product-packages and pricing	0.0708	7.08%
After-sales customer service	0.0171	1.71%
Social impact	0.0317	3.17%
Economic impact	0.0755	7.55%
Customer response	0.0100	1.00%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-20 judgment analysis) are presented in Table 4-72.

Table 4-72 Global priorities and global weights for alternatives –Expert-20 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1925	19.25%
Data	0.6571	65.71%
VAS	0.1504	15.04%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-20 preferred Technology as the most important factor(s). In case of sub-factors, Expert-20 preferred Technological up-gradation as most important. Tables show that Expert-20 preferred Data service most than all other alternatives with 57.37% global weight followed by Voice Service and VAS.

4.6.21 AHP analysis: Expert 21

Final calculation result for Expert-21 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-21 judgment analysis) are presented in Table 4-73.

Table 4-73 Global priorities and global weights for factors –Expert-21 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.7248	72.48%
Sales and Marketing	0.1248	12.48%
Ripple effect	0.1504	15.04%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-21 judgment analysis) are presented in Table 4-74.

Table 4-74 Global priorities and global weights for sub-factors –Expert-21 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.5788	57.88%
Technological up-gradation	0.0760	7.60%
Knowledge development	0.0699	6.99%
Advertising and branding	0.0174	1.74%
Customer classification and analysis	0.0132	1.32%
Product-packages and pricing	0.0764	7.64%
After-sales customer service	0.0178	1.78%
Social impact	0.0583	5.83%
Economic impact	0.0774	7.74%
Customer response	0.0147	1.47%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-21 judgment analysis) are presented in Table 4-75.

Table 4-75 Global priorities and global weights for alternatives –Expert-21 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1497	14.97%
Data	0.6758	67.58%
VAS	0.1744	17.44%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-21 preferred Technology as the most important factor(s). In case of sub-factors, Expert-21 preferred Network coverage and quality as most important. Tables show that Expert-21 preferred Data service most than all other alternatives with 67.58% global weight followed by VAS and Voice Service.

4.6.22 AHP analysis: Expert 22

Final calculation result for Expert-22 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global Priorities & Global Weights for Factors (under Expert-21 judgment analysis) are presented in Table 4-76.

Table 4-76 Global priorities and global weights for factors –Expert-22 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6250	62.50%
Sales and Marketing	0.2385	23.85%
Ripple effect	0.1365	13.65%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-22 judgment analysis) are presented in Table 4-77.

Table 4-77 Global priorities and global weights for sub-factors –Expert-22 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4347	43.47%
Technological up-gradation	0.1432	14.32%
Knowledge development	0.0471	4.71%
Advertising and branding	0.0587	5.87%
Customer classification and analysis	0.0500	5.00%
Product-packages and pricing	0.0710	7.10%
After-sales customer service	0.0587	5.87%
Social impact	0.0366	3.66%
Economic impact	0.0839	8.39%
Customer response	0.0160	1.60%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-22 judgment analysis) are presented in Table 4-78.

Table 4-78 Global priorities and global weights for alternatives –Expert-22 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2074	20.74%
Data	0.6228	62.28%
VAS	0.1698	16.98%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-22 preferred Technology as the most important factor(s). In case of sub-factors, Expert-22 preferred Network coverage and quality as most important. Tables show that Expert-22 preferred Data service most than all other alternatives with 62.28% global weight followed by Voice Service and VAS.

4.6.23 AHP analysis: Expert 23

Final calculation result for Expert-23 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-23 judgment analysis) are presented in Table 4-79.

Table 4-79 Global priorities and global weights for factors –Expert-23 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6738	67.38%
Sales and Marketing	0.2256	22.56%
Ripple effect	0.1006	10.06%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-23 judgment analysis) are presented in Table 4-80.

Table 4-80 Global priorities and global weights for sub-factors –Expert-23 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4833	48.33%
Technological up-gradation	0.1312	13.12%
Knowledge development	0.0593	5.93%
Advertising and branding	0.0498	4.98%
Customer classification and analysis	0.0335	3.35%
Product-packages and pricing	0.1328	13.28%
After-sales customer service	0.0095	0.95%
Social impact	0.0438	4.38%
Economic impact	0.0490	4.90%
Customer response	0.0078	0.78%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-23 judgment analysis) are presented in Table 4-81.

Table 4-81 Global priorities and global weights for alternatives –Expert-23 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1898	18.98%
Data	0.5003	50.03%
VAS	0.3098	30.98%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-23 preferred Technology as the most important factor(s). In case of sub-factors, Expert-23 preferred Network coverage and quality as most important. Tables show that Expert-23 preferred Data service most than all other alternatives with 50.03% global weight followed by VAS and Voice Service.

4.6.24 AHP analysis: Expert 24

Final calculation result for Expert-24 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-24 judgment analysis) are presented in Table 4-82.

Table 4-82 Global priorities and global weights for factors –Expert-24 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6144	61.44%
Sales and Marketing	0.2684	26.84%
Ripple effect	0.1172	11.72%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-24 judgment analysis) are presented in Table 4-83.

Table 4-83 Global priorities and global weights for sub-factors –Expert-24 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4407	44.07%
Technological up-gradation	0.1196	11.96%
Knowledge development	0.0541	5.41%
Advertising and branding	0.1098	10.98%
Customer classification and analysis	0.0623	6.23%
Product-packages and pricing	0.0748	7.48%
After-sales customer service	0.0215	2.15%
Social impact	0.0720	7.20%
Economic impact	0.0315	3.15%
Customer response	0.0137	1.37%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-24 judgment analysis) are presented in Table 4-84.

Table 4-84 Global priorities and global weights for alternatives –Expert-24 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.5127	51.27%
Data	0.3728	37.28%
VAS	0.1145	11.45%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-24 preferred Technology as the most important factor(s). In case of sub-factors, Expert-24 preferred Network coverage and quality as most important. Tables show that Expert-24 preferred Voice service most than all other alternatives with 51.27% global weight followed by Data service and VAS.

4.6.25 AHP analysis: Expert 25

Final calculation result for Expert-25 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-25 judgment analysis) are presented in Table 4-85.

Table 4-85 Global priorities and global weights for factors –Expert-25 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.7428	74.28%
Sales and Marketing	0.1939	19.39%
Ripple effect	0.0632	6.32%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-25 judgment analysis) are presented in Table 4-86.

Table 4-86 Global priorities and global weights for sub-factors –Expert-25 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.5518	55.18%
Technological up-gradation	0.1440	14.40%
Knowledge development	0.0470	4.70%
Advertising and branding	0.0461	4.61%
Customer classification and analysis	0.0169	1.69%
Product-packages and pricing	0.1234	12.34%
After-sales customer service	0.0075	0.75%
Social impact	0.0123	1.23%
Economic impact	0.0470	4.70%
Customer response	0.0040	0.40%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-25 judgment analysis) are presented in Table 4-87.

Table 4-87 Global priorities and global weights for alternatives –Expert-25 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1101	11.01%
Data	0.7031	70.31%
VAS	0.1868	18.68%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-25 preferred Technology as the most important factor(s). In case of sub-factors, Expert-25 preferred Network coverage and quality as most important. Tables show that Expert-25 preferred Voice service most than all other alternatives with 70.31% global weight followed by VAS and Voice service.

4.6.26 AHP analysis: Expert 26

Final calculation result for Expert-26 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-26 judgment analysis) are presented in Table 4-88.

Table 4-88 Global priorities and global weights for factors –Expert-26 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.7514	75.14%
Sales and Marketing	0.1782	17.82%
Ripple effect	0.0704	7.04%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-26 judgment analysis) are presented in Table 4-89.

Table 4-89 Global priorities and global weights for sub-factors –Expert-26 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3338	33.38%
Technological up-gradation	0.3547	35.47%
Knowledge development	0.0628	6.28%
Advertising and branding	0.0445	4.45%
Customer classification and analysis	0.0445	4.45%
Product-packages and pricing	0.0445	4.45%
After-sales customer service	0.0445	4.45%
Social impact	0.0153	1.53%
Economic impact	0.0505	5.05%
Customer response	0.0046	0.46%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-26 judgment analysis) are presented in Table 4-90.

Table 4-90 Global priorities and global weights for alternatives –Expert-26 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1693	16.93%
Data	0.6074	60.74%
VAS	0.2233	22.33%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-26 preferred Technology as the most important factor(s). In case of sub-factors, Expert-26 preferred Technological up-gradation as most important. Tables show that Expert-26 preferred Data service most than all other alternatives with 60.74% global weight followed by VAS and Voice service.

4.6.27 AHP analysis: Expert 27

Final calculation result for Expert-27 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-27 judgment analysis) are presented in Table 4-91.

Table 4-91 Global priorities and global weights for factors –Expert-27 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6483	64.83%
Sales and Marketing	0.2297	22.97%
Ripple effect	0.1220	12.20%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-27 judgment analysis) are presented in Table 4-92.

Table 4-92 Global priorities and global weights for sub-factors –Expert-27 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3849	38.49%
Technological up-gradation	0.1616	16.16%
Knowledge development	0.1018	10.18%
Advertising and branding	0.0579	5.79%
Customer classification and analysis	0.0311	3.11%
Product-packages and pricing	0.1247	12.47%
After-sales customer service	0.0160	1.60%
Social impact	0.0116	1.16%
Economic impact	0.0799	7.99%
Customer response	0.0305	3.05%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-27 judgment analysis) are presented in Table 4-93.

Table 4-93 Global priorities and global weights for alternatives –Expert-27 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2582	25.82%
Data	0.6375	63.75%
VAS	0.1043	10.43%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-27 preferred Technology as the most important factor(s). In case of sub-factors, Expert-27 preferred Network coverage and quality as most important. Tables show that Expert-27 preferred Data service most than all other alternatives with 63.75% global weight followed by Voice service and VAS.

4.6.28 AHP analysis: Expert 28

Final calculation result for Expert-28 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-28 judgment analysis) are presented in Table 4-94.

Table 4-94 Global priorities and global weights for factors –Expert-28 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-28 judgment analysis) are presented in Table 4-95.

Table 4-95 Global priorities and global weights for sub-factors –Expert-28 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1763	17.63%
Technological up-gradation	0.3203	32.03%
Knowledge development	0.0970	9.70%
Advertising and branding	0.1450	14.50%
Customer classification and analysis	0.0300	3.00%
Product-packages and pricing	0.0577	5.77%
After-sales customer service	0.0166	1.66%
Social impact	0.0392	3.92%
Economic impact	0.0932	9.32%
Customer response	0.0247	2.47%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-28 judgment analysis) are presented in Table 4-96.

Table 4-96 Global priorities and global weights for alternatives –Expert-28 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2335	23.35%
Data	0.6436	64.36%
VAS	0.1229	12.29%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-28 preferred Technology as the most important factor(s). In case of sub-factors, Expert-28 preferred Technological up-gradation as most important. Tables show that Expert-28 preferred Data service most than all other alternatives with 64.36% global weight followed by Voice service and VAS.

4.6.29 AHP analysis: Expert 29

Final calculation result for Expert-29 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-29 judgment analysis) are presented in Table 4-97.

Table 4-97 Global priorities and global weights for factors –Expert-29 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6694	66.94%
Sales and Marketing	0.2426	24.26%
Ripple effect	0.0879	8.79%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-29 judgment analysis) are presented in Table 4-98.

Table 4-98 Global priorities and global weights for sub-factors –Expert-29 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4481	44.81%
Technological up-gradation	0.1624	16.24%
Knowledge development	0.0589	5.89%
Advertising and branding	0.0652	6.52%
Customer classification and analysis	0.0332	3.32%
Product-packages and pricing	0.1316	13.16%
After-sales customer service	0.0127	1.27%
Social impact	0.0077	0.77%
Economic impact	0.0589	5.89%
Customer response	0.0213	2.13%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-29 judgment analysis) are presented in Table 4-99.

Table 4-99 Global priorities and global weights for alternatives –Expert-29 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2426	24.26%
Data	0.6694	66.94%
VAS	0.0879	8.79%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-29 preferred Technology as the most important factor(s). In case of sub-factors,

Expert-29 preferred Network coverage and quality as most important. Tables show that Expert-29 preferred Data service most than all other alternatives with 66.94% global weight followed by Voice service and VAS.

4.6.30 AHP analysis: Expert 30

Final calculation result for Expert-30 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-30 judgment analysis) are presented in Table 4-100.

Table 4-100 Global priorities and global weights for factors –Expert-30 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6910	69.10%
Sales and Marketing	0.2176	21.76%
Ripple effect	0.0914	9.14%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-30 judgment analysis) are presented in Table 4-101.

Table 4-101 Global priorities and global weights for sub-factors –Expert-30 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.5025	50.25%
Technological up-gradation	0.1256	12.56%
Knowledge development	0.0628	6.28%
Advertising and branding	0.0617	6.17%
Customer classification and analysis	0.0325	3.25%
Product-packages and pricing	0.1099	10.99%
After-sales customer service	0.0136	1.36%
Social impact	0.0274	2.74%
Economic impact	0.0548	5.48%
Customer response	0.0091	0.91%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-30 judgment analysis) are presented in Table 4-102.

Table 4-102 Global priorities and global weights for alternatives –Expert-30 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.1433	14.33%
Data	0.6343	63.43%
VAS	0.2224	22.24%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-30 preferred Technology as the most important factor(s). In case of sub-factors, Expert-30 preferred Network coverage and quality as most important. Tables show that Expert-30 preferred Data service most than all other alternatives with 63.43% global weight followed by VAS and Voice service.

4.6.31 Consolidation and analysis of industry experts' opinion on pair-wise comparison

In the previous sub-sections, individual opinion of all 30 industry experts are presented. For consolidation of industry experts' opinion, all the global weights for criteria, sub-criteria and alternatives for all 30 industry experts are taken. Then by calculating the average of these values, consolidated results of industry experts' opinion are derived. To derive consolidated results, Microsoft Excel Spreadsheet is used.

Consolidated results for all 30 industry experts' feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables and graphs.

Global priorities and global weights for factors (consolidated result of all industry experts' judgment) are presented in Table 4-103, and their graphical representation is shown in Figure 4:27.

Table 4-103 Global priorities and global weights for factors – consolidated result of all industry experts' judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6123	61.23%
Sales and Marketing	0.2561	25.61%
Ripple effect	0.1316	13.16%
Total	1.0000	100.00%

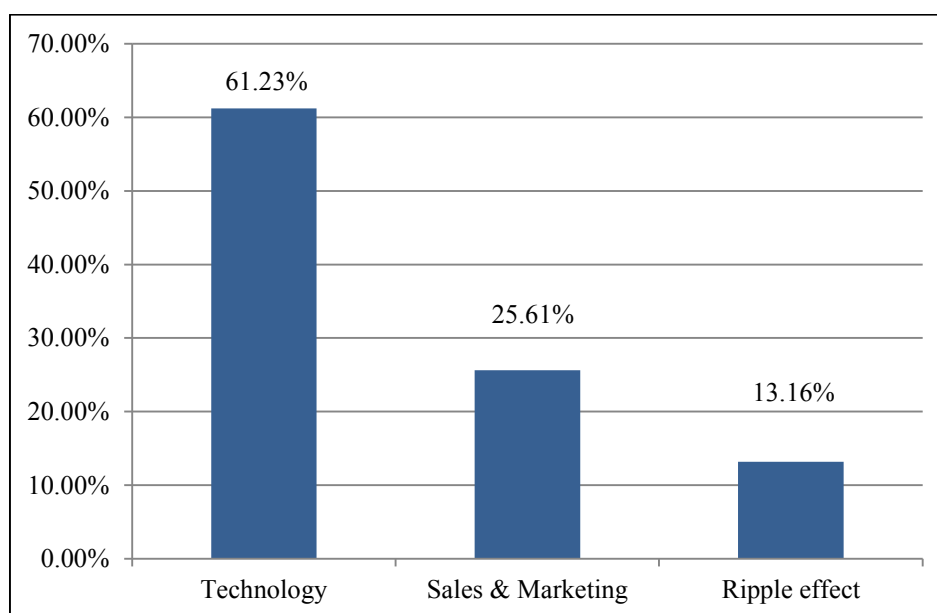


Figure 4:27 Graphical representation: global weights for factors – consolidated result of all industry experts' judgment

Global priorities and global weights for sub-factors (consolidated result of all industry experts' judgment) are presented in Table 4-104, and their graphical representation is shown in Figure 4:28.

Table 4-104 Global priorities and global weights for sub-factors – consolidated result of all industry experts’ judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3388	33.88%
Technological up-gradation	0.2044	20.44%
Knowledge development	0.0691	6.91%
Advertising and branding	0.0790	7.90%
Customer classification and analysis	0.0514	5.14%
Product-packages and pricing	0.1005	10.05%
After-sales customer service	0.0252	2.52%
Social impact	0.0316	3.16%
Economic impact	0.0706	7.06%
Customer response	0.0294	2.94%
Total	1.0000	100.00%

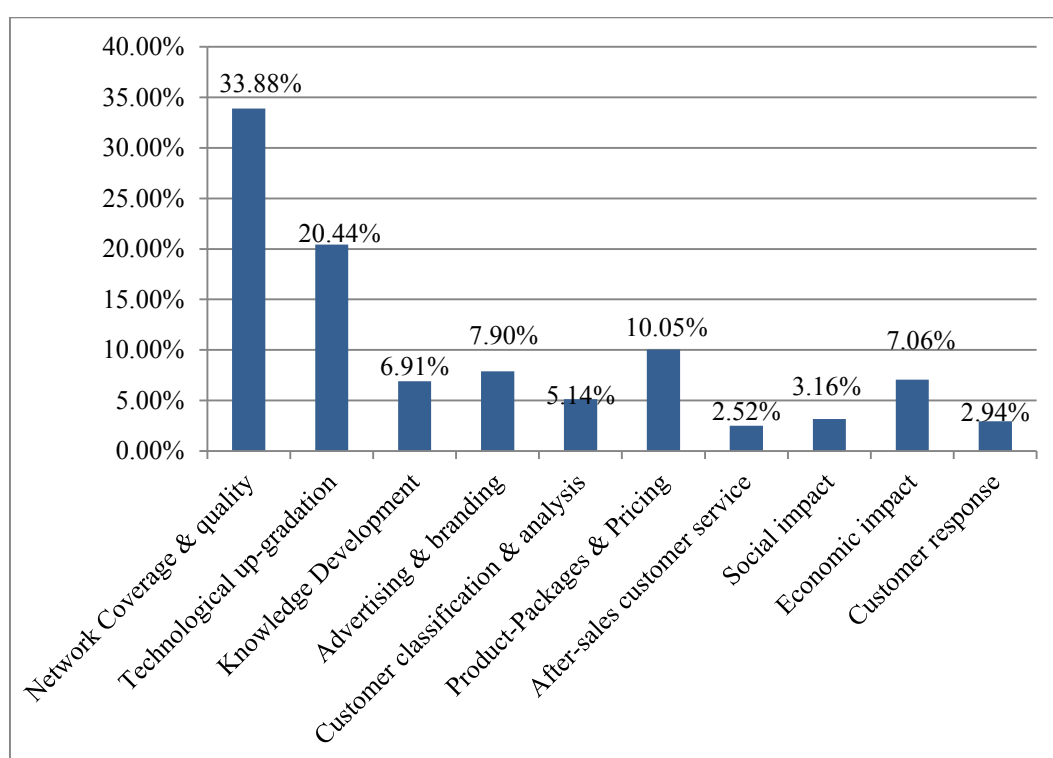


Figure 4:28 Graphical representation: global weights for sub-factors – consolidated result of all industry experts’ judgment

Global priorities and global weights for alternatives (consolidated result of all industry experts’ judgment) are presented in Table 4-105, and their graphical representation is shown in Figure 4:29.

Table 4-105 Global priorities and global weights for alternatives – consolidated result of all industry experts’ judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2639	26.39%
Data	0.5627	56.27%
VAS	0.1735	17.35%
Total	1.0000	100.00%

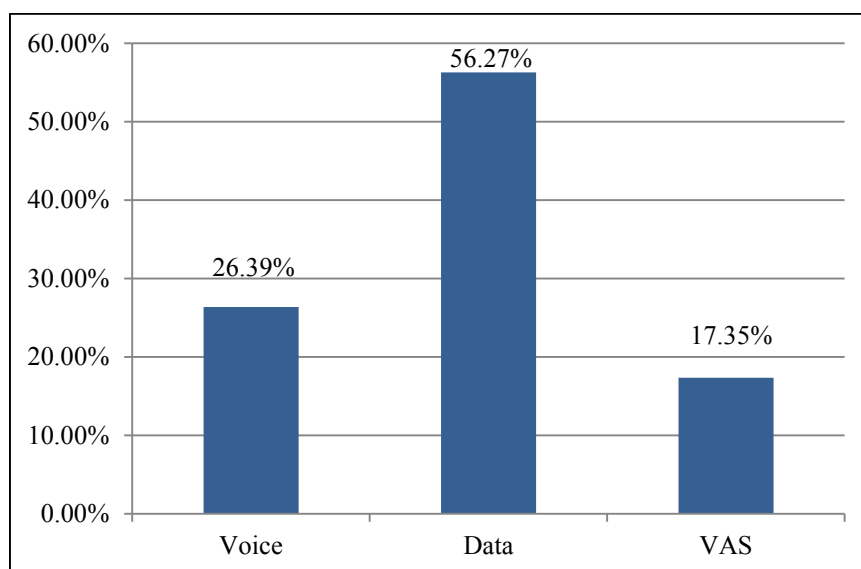


Figure 4:29 Graphical representation: global weights for alternatives – consolidated result of all industry experts’ judgment

From above tables and graphs, it is found that, according to combined opinion of industry experts’, Technology is the most important factor with 61.23% global weight for successful adoption of 4G technology. In case of sub-factors, Network coverage and quality is the most important one with 33.88% global weight, followed by Technological up-gradation with 20.44%, Product-packages and pricing with 10.05% and Advertising and branding with 7.90% global weight. According to industry experts’ combined opinion, Data service is the most preferred option than other two alternatives with 56.27% combined global weight followed by Voice service (26.39%) and VAS (17.35%).

Individual and consolidated opinion of all industry experts are provided in this section. Following section provides the same for all independent experts.

4.7 Analysis of Independent Experts' Opinion on Pair-wise Comparison through AHP

This section provides independent experts' opinion on pair-wise comparison through AHP.

4.7.1 AHP analysis: Expert 31

Final result for Expert-31 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-31 judgment analysis) are presented in Table 4-106.

Table 4-106 Global priorities and global weights for factors –Expert-31 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6694	66.94%
Sales and Marketing	0.2426	24.26%
Ripple effect	0.0879	8.79%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-31 judgment analysis) are presented in Table 4-107.

Table 4-107 Global priorities and global weights for sub-factors –Expert-31 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2869	28.69%
Technological up-gradation	0.2869	28.69%
Knowledge development	0.0956	9.56%
Advertising and branding	0.0232	2.32%
Customer classification and analysis	0.0957	9.57%
Product-packages and pricing	0.0542	5.42%
After-sales customer service	0.0696	6.96%
Social impact	0.0103	1.03%
Economic impact	0.0540	5.40%
Customer response	0.0236	2.36%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-31 judgment analysis) are presented in Table 4-108.

Table 4-108 Global priorities and global weights for alternatives –Expert-31 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2489	24.89%
Data	0.4728	47.28%
VAS	0.2783	27.83%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-31 preferred Technology as the most important factor(s). In case of sub-factors, Expert-31 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-31 preferred Data service most than all other alternatives with 47.28% global weight followed by VAS and Voice service.

4.7.2 AHP analysis: Expert 32

Final calculation result for Expert-32 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-32 judgment analysis) are presented in Table 4-109.

Table 4-109 Global priorities and global weights for factors –Expert-32 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6910	69.10%
Sales and Marketing	0.2176	21.76%
Ripple effect	0.0914	9.14%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-32 judgment analysis) are presented in Table 4-110.

Table 4-110 Global priorities and global weights for sub-factors –Expert-32 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2961	29.61%
Technological up-gradation	0.2961	29.61%
Knowledge development	0.0987	9.87%
Advertising and branding	0.1259	12.59%
Customer classification and analysis	0.0490	4.90%
Product-packages and pricing	0.0271	2.71%
After-sales customer service	0.0156	1.56%
Social impact	0.0405	4.05%
Economic impact	0.0354	3.54%
Customer response	0.0155	1.55%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-32 judgment analysis) are presented in Table 4-111.

Table 4-111 Global priorities and global weights for alternatives –Expert-32 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2300	23.00%
Data	0.6043	60.43%
VAS	0.1657	16.57%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-32 preferred Technology as the most important factor(s). In case of sub-factors, Expert-32 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-32 preferred Data service most than all other alternatives with 60.43% global weight followed by Voice service and VAS.

4.7.3 AHP analysis: Expert 33

Final result for Expert-33 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-33 judgment analysis) are presented in Table 4-112.

Table 4-112 Global priorities and global weights for factors –Expert-33 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6910	69.10%
Sales and Marketing	0.2176	21.76%
Ripple effect	0.0914	9.14%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-33 judgment analysis) are presented in Table 4-113.

Table 4-113 Global priorities and global weights for sub-factors –Expert-33 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.4774	47.74%
Technological up-gradation	0.1504	15.04%
Knowledge development	0.0632	6.32%
Advertising and branding	0.1125	11.25%
Customer classification and analysis	0.0177	1.77%
Product-packages and pricing	0.0566	5.66%
After-sales customer service	0.0309	3.09%
Social impact	0.0206	2.06%
Economic impact	0.0616	6.16%
Customer response	0.0092	0.92%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-33 judgment analysis) are presented in Table 4-114.

Table 4-114 Global priorities and global weights for alternatives –Expert-33 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.4440	44.40%
Data	0.3480	34.80%
VAS	0.2080	20.80%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-33 preferred Technology as the most important factor(s). In case of sub-factors,

Expert-33 preferred Network coverage and quality as most important. Tables show that Expert-33 preferred Voice service most than all other alternatives with 44.40% global weight followed by Data service and VAS.

4.7.4 AHP analysis: Expert 34

Final calculation result for Expert-34 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-34 judgment analysis) are presented in Table 4-115.

Table 4-115 Global priorities and global weights for factors –Expert-34 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6955	69.55%
Sales and Marketing	0.2291	22.91%
Ripple effect	0.0754	7.54%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-34 judgment analysis) are presented in Table 4-116.

Table 4-116 Global priorities and global weights for sub-factors –Expert-34 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2981	29.81%
Technological up-gradation	0.2981	29.81%
Knowledge development	0.0994	9.94%
Advertising and branding	0.0833	8.33%
Customer classification and analysis	0.0208	2.08%
Product-packages and pricing	0.0833	8.33%
After-sales customer service	0.0417	4.17%
Social impact	0.0076	0.76%
Economic impact	0.0508	5.08%
Customer response	0.0170	1.70%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-34 judgment analysis) are presented in Table 4-117.

Table 4-117 Global priorities and global weights for alternatives –Expert-34 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2008	20.08%
Data	0.6351	63.51%
VAS	0.1641	16.41%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-34 preferred Technology as the most important factor(s). In case of sub-factors, Expert-34 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-34 preferred Data service most than all other alternatives with 63.51% global weight followed by Voice service and VAS.

4.7.5 AHP analysis: Expert 35

Final calculation result for Expert-35 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-35 judgment analysis) are presented in Table 4-118.

Table 4-118 Global priorities and global weights for factors –Expert-35 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-35 judgment analysis) are presented in Table 4-119.

Table 4-119 Global priorities and global weights for sub-factors –Expert-35 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1660	16.60%
Technological up-gradation	0.3720	37.20%
Knowledge development	0.0556	5.56%
Advertising and branding	0.0888	8.88%
Customer classification and analysis	0.0750	7.50%
Product-packages and pricing	0.0619	6.19%
After-sales customer service	0.0236	2.36%
Social impact	0.0524	5.24%
Economic impact	0.0524	5.24%
Customer response	0.0524	5.24%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-35 judgment analysis) are presented in Table 4-120.

Table 4-120 Global priorities and global weights for alternatives –Expert-35 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2573	25.73%
Data	0.6361	63.61%
VAS	0.1065	10.65%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-35 preferred Technology as the most important factor(s). In case of sub-factors, Expert-35 preferred Technological up-gradation as most important. Tables show that Expert-35 preferred Data service most than all other alternatives with 63.61% global weight followed by Voice service and VAS.

4.7.6 AHP analysis: Expert 36

Final result for Expert-36 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-36 judgment analysis) are presented in Table 4-121.

Table 4-121 Global priorities and global weights for factors –Expert-36 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.5936	59.36%
Sales and Marketing	0.2493	24.93%
Ripple effect	0.1571	15.71%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-36 judgment analysis) are presented in Table 4-122.

Table 4-122 Global priorities and global weights for sub-factors –Expert-36 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2375	23.75%
Technological up-gradation	0.2375	23.75%
Knowledge development	0.1187	11.87%
Advertising and branding	0.1261	12.61%
Customer classification and analysis	0.0410	4.10%
Product-packages and pricing	0.0668	6.68%
After-sales customer service	0.0155	1.55%
Social impact	0.1085	10.85%
Economic impact	0.0342	3.42%
Customer response	0.0144	1.44%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-36 judgment analysis) are presented in Table 4-123.

Table 4-123 Global priorities and global weights for alternatives –Expert-36 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2291	22.91%
Data	0.6955	69.55%
VAS	0.0754	7.54%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-36 preferred Technology as the most important factor(s). In case of sub-factors,

Expert-36 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-36 preferred Data service most than all other alternatives with 69.55% global weight followed by Voice service and VAS.

4.7.7 AHP analysis: Expert 37

Final calculation result for Expert-37 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-37 judgment analysis) are presented in Table 4-124.

Table 4-124 Global priorities and global weights for factors –Expert-37 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6000	60.00%
Sales and Marketing	0.2000	20.00%
Ripple effect	0.2000	20.00%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-37 judgment analysis) are presented in Table 4-125.

Table 4-125 Global priorities and global weights for sub-factors –Expert-37 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2400	24.00%
Technological up-gradation	0.2400	24.00%
Knowledge development	0.1200	12.00%
Advertising and branding	0.0781	7.81%
Customer classification and analysis	0.0276	2.76%
Product-packages and pricing	0.0552	5.52%
After-sales customer service	0.0391	3.91%
Social impact	0.0987	9.87%
Economic impact	0.0622	6.22%
Customer response	0.0392	3.92%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-37 judgment analysis) are presented in Table 4-126.

Table 4-126 Global priorities and global weights for alternatives –Expert-37 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2411	24.11%
Data	0.6443	64.43%
VAS	0.1146	11.46%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-37 preferred Technology as the most important factor(s). In case of sub-factors, Expert-37 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-37 preferred Data service most than all other alternatives with 64.43% global weight followed by Voice service and VAS.

4.7.8 AHP analysis: Expert 38

Final calculation result for Expert-38 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables.

Global priorities and global weights for factors (under Expert-38 judgment analysis) are presented in Table 4-127.

Table 4-127 Global priorities and global weights for factors –Expert-38 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.7172	71.72%
Sales and Marketing	0.1947	19.47%
Ripple effect	0.0881	8.81%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-38 judgment analysis) are presented in Table 4-128.

Table 4-128 Global priorities and global weights for sub-factors –Expert-38 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.1351	13.51%
Technological up-gradation	0.5240	52.40%
Knowledge development	0.0581	5.81%
Advertising and branding	0.1189	11.89%
Customer classification and analysis	0.0141	1.41%
Product-packages and pricing	0.0392	3.92%
After-sales customer service	0.0225	2.25%
Social impact	0.0541	5.41%
Economic impact	0.0103	1.03%
Customer response	0.0236	2.36%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-38 judgment analysis) are presented in Table 4-129.

Table 4-129 Global priorities and global weights for alternatives –Expert-38 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2185	21.85%
Data	0.6891	68.91%
VAS	0.0924	9.24%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-38 preferred Technology as the most important factor(s). In case of sub-factors, Expert-38 preferred Technological up-gradation as most important. Tables show that Expert-38 preferred Data service most than all other alternatives with 68.91% global weight followed by Voice service and VAS.

4.7.9 AHP analysis: Expert 39

Final result for Expert-39 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-39 judgment analysis) are presented in Table 4-130.

Table 4-130 Global priorities and global weights for factors –Expert-39 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6608	66.08%
Sales and Marketing	0.2081	20.81%
Ripple effect	0.1311	13.11%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-39 judgment analysis) are presented in Table 4-131.

Table 4-131 Global priorities and global weights for sub-factors –Expert-39 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2832	28.32%
Technological up-gradation	0.2832	28.32%
Knowledge development	0.0944	9.44%
Advertising and branding	0.0494	4.94%
Customer classification and analysis	0.0253	2.53%
Product-packages and pricing	0.0180	1.80%
After-sales customer service	0.1154	11.54%
Social impact	0.0866	8.66%
Economic impact	0.0273	2.73%
Customer response	0.0172	1.72%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-39 judgment analysis) are presented in Table 4-132.

Table 4-132 Global priorities and global weights for alternatives –Expert-39 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.4484	44.84%
Data	0.3751	37.51%
VAS	0.1765	17.65%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-39 preferred Technology as the most important factor(s). In case of sub-factors,

Expert-39 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-39 preferred Voice service most than all other alternatives with 44.84% global weight followed by Data service and VAS.

4.7.10 AHP analysis: Expert 40

Final result for Expert-40 feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables. Global priorities and global weights for factors (under Expert-40 judgment analysis) are presented in Table 4-133.

Table 4-133 Global priorities and global weights for factors –Expert-40 judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6738	67.38%
Sales and Marketing	0.2256	22.56%
Ripple effect	0.1006	10.06%
Total	1.0000	100.00%

Global priorities and global weights for sub-factors (under Expert-40 judgment analysis) are presented in Table 4-134.

Table 4-134 Global priorities and global weights for sub-factors –Expert-40 judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2695	26.95%
Technological up-gradation	0.2695	26.95%
Knowledge development	0.1348	13.48%
Advertising and branding	0.1100	11.00%
Customer classification and analysis	0.0267	2.67%
Product-packages and pricing	0.0623	6.23%
After-sales customer service	0.0267	2.67%
Social impact	0.0497	4.97%
Economic impact	0.0313	3.13%
Customer response	0.0197	1.97%
Total	1.0000	100.00%

Global priorities and global weights for alternatives (under Expert-40 judgment analysis) are presented in Table 4-135.

Table 4-135 Global priorities and global weights for alternatives –Expert-40 judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.5531	55.31%
Data	0.2865	28.65%
VAS	0.1603	16.03%
Total	1.0000	100.00%

From above tables, it is found that for 4G technology adoption strategy formulation, Expert-40 preferred Technology as the most important factor(s). In case of sub-factors, Expert-40 preferred Network coverage and quality and Technological up-gradation equally as most important. Tables show that Expert-40 preferred Voice service most than all other alternatives with 55.31% global weight followed by Data service and VAS.

4.7.11 Consolidation and analysis of independent experts' opinion on pair-wise comparison

In the previous sub-sections, individual opinion of all 10 independent experts are presented. For result consolidation all the global weights for criteria, sub-criteria and alternatives for all 10 independent experts are taken and then by calculating the average of these values the consolidated results are derived. Calculation results for all 10 independent experts' feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables and graphs. Global priorities and global weights for factors (consolidated result of all independent experts' judgment) are presented, in Table 4-136 and their graphical representation is shown in Figure 4:30.

Table 4-136 Global priorities and global weights for factors – consolidated result of all independent experts' judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6586	65.86%
Sales and Marketing	0.2234	22.34%
Ripple effect	0.1180	11.80%
Total	1.0000	100.00%

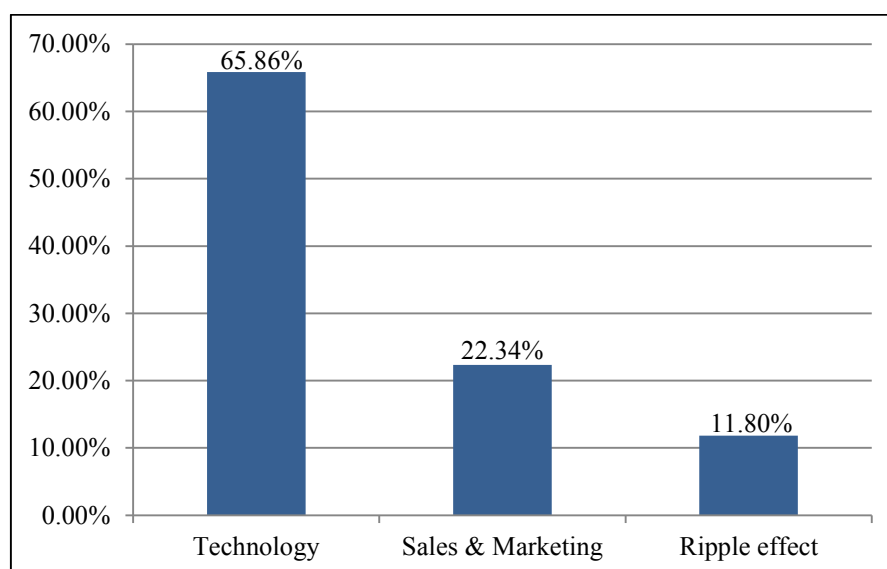


Figure 4:30 Graphical representation: global weights for factors – consolidated result of all independent experts’ judgment

Global priorities and global weights for sub-factors (consolidated result of all independent experts’ judgment) are presented in Table 4-137 and their graphical representation is shown in Figure 4:31.

Table 4-137 Global priorities and global weights for sub-factors – consolidated result of all independent experts’ judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.2690	26.90%
Technological up-gradation	0.2958	29.58%
Knowledge development	0.0938	9.38%
Advertising and branding	0.0916	9.16%
Customer classification and analysis	0.0393	3.93%
Product-packages and pricing	0.0525	5.25%
After-sales customer service	0.0400	4.00%
Social impact	0.0529	5.29%
Economic impact	0.0419	4.19%
Customer response	0.0232	2.32%
Total	1.0000	100.00%

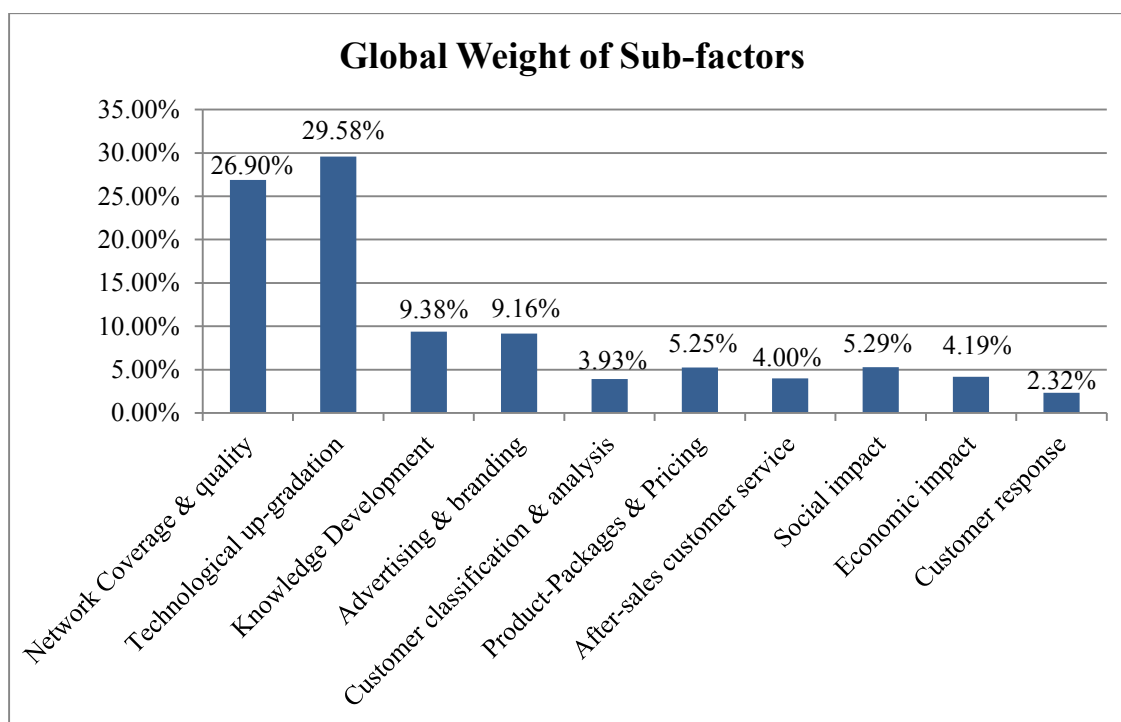


Figure 4:31 Graphical representation: global weights for sub-factors – consolidated result of all independent experts’ judgment

Global priorities and global weights for alternatives (consolidated result of all independent experts’ judgment) are presented in Table 4-138 and their graphical representation is shown in Figure 4:32.

Table 4-138 Global priorities and global weights for alternatives – consolidated result of all independent experts’ judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.3071	30.71%
Data	0.5387	53.87%
VAS	0.1542	15.42%
Total	1.0000	100.00%

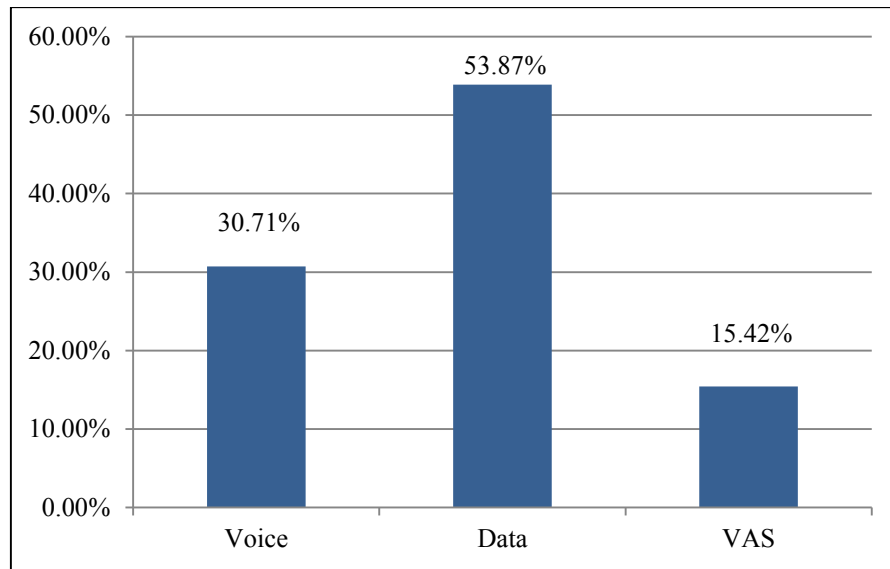


Figure 4.32 Graphical representation: global weights for alternatives – consolidated result of all independent experts' judgment

From above tables and graphs, it is found that, according to combined opinion of all 10 independent experts, Technology is the most important factor with 65.86% Global weight for successful adoption of 4G technology. In case of sub-factors, Technological up-gradation is the most important one with 29.58% global weight, followed by Network coverage and quality with 26.90%, Knowledge development with 9.38%% and Advertising and branding with 9.16% global weight.

According to combined opinion of independent experts, Data service is the most preferred than other two alternatives with 53.87% combined global weight followed by Voice service (30.71%) and VAS (15.42%).

4.8 Consolidation and Analysis of All (Industry and Independent) Experts' Opinion on Pair-wise Comparison

In the previous sections (section 4.6 and 4.7), individual and combined opinion of all industry experts and independent experts are presented. In this section the combined result i.e. consolidated opinion of all (industry and independent) experts is derived which provides the final outcome of this research work. For result consolidation, all the global

weights for criteria, sub-criteria and alternatives for all 40 experts are taken and then by calculating the average of these values the final results are derived. Final calculation results for all 40 experts' feedback i.e. global priorities and global weights for factors, sub-factors and alternatives are presented in following tables and graphs.

Global priorities and global weights for factors (consolidated result of all experts' judgment) are presented in Table 4-139, and their graphical representation is shown in Figure 4:33.

Table 4-139 Global priorities and global weights for factors – consolidated result of all (industry and independent) experts' judgment

Factors	Global Priorities of Factors	Global Weight of Factors
Technology	0.6239	62.39%
Sales and Marketing	0.2479	24.79%
Ripple effect	0.1282	12.82%
Total	1.0000	100.00%

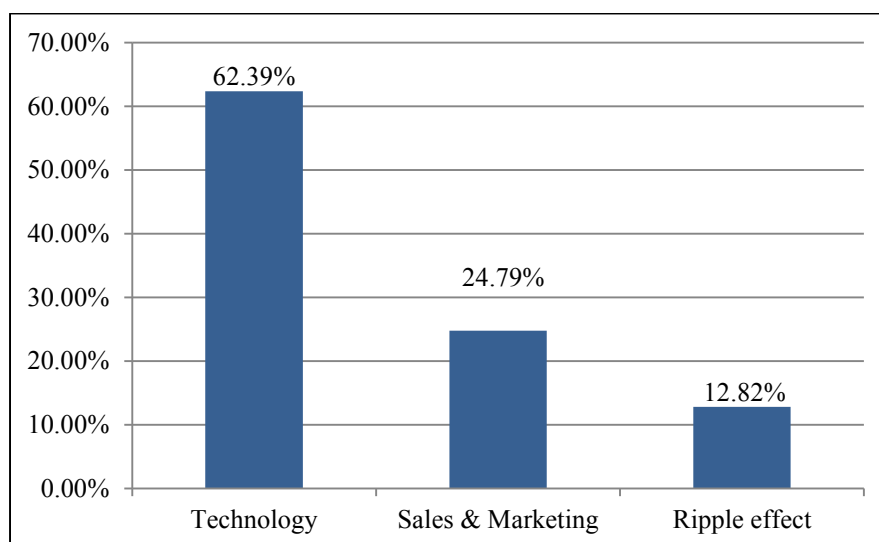


Figure 4:33 Graphical representation: global weights for factors – consolidated result of all experts' judgment

Global priorities and global weights for sub-factors (consolidated result of all experts' judgment) are presented in Table 4-140, and their graphical representation is shown in Figure 4:34.

Table 4-140 Global priorities and global weights for sub-factors – consolidated result of all (industry and independent) experts’ judgment

Sub-Factors	Global Priorities of Sub-factors	Global Weight of Sub-factors
Network coverage and quality	0.3214	32.14%
Technological up-gradation	0.2272	22.72%
Knowledge development	0.0753	7.53%
Advertising and branding	0.0822	8.22%
Customer classification and analysis	0.0484	4.84%
Product-packages and pricing	0.0885	8.85%
After-sales customer service	0.0289	2.89%
Social impact	0.0369	3.69%
Economic impact	0.0634	6.34%
Customer response	0.0278	2.78%
Total	1.0000	100.00%

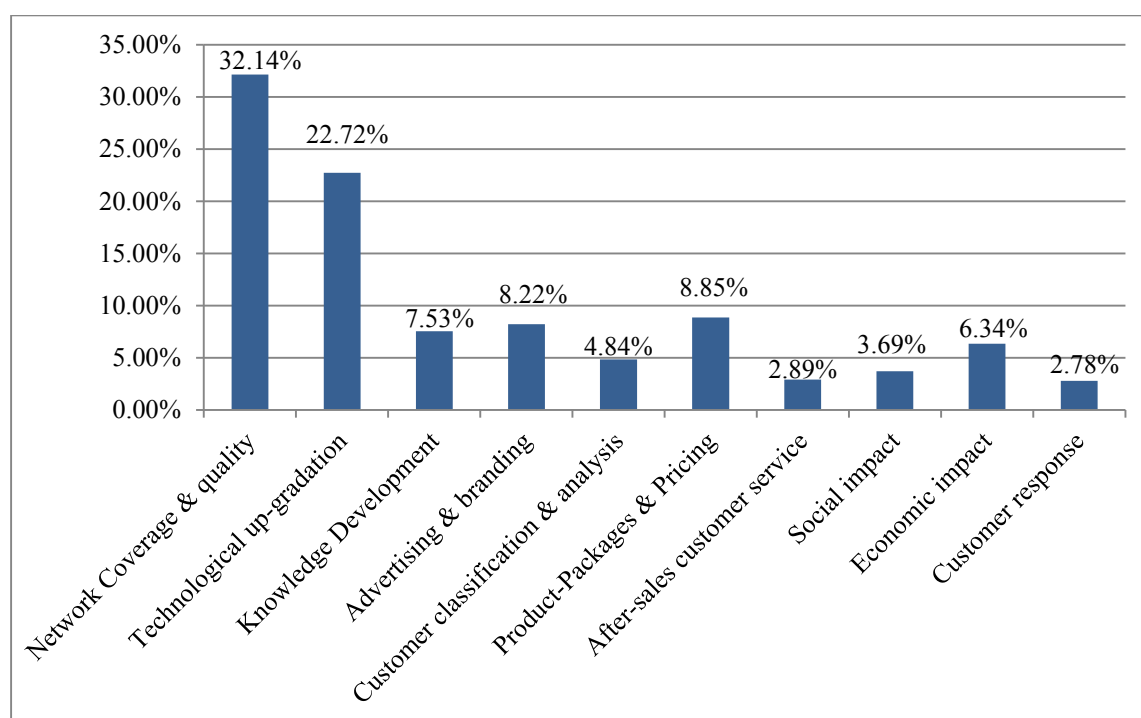


Figure 4:34 Graphical representation: global weights for sub-factors – consolidated result of all experts’ judgment

Global priorities and global weights for alternatives (consolidated result of all experts’ judgment) are presented in Table 4-141, and their graphical representation is shown in Figure 4:35.

Table 4-141 Global priorities and global weights for alternatives – consolidated result of all (industry and independent) experts’ judgment

Alternatives	Global Priorities of Alternatives	Global Weight of Alternatives
Voice	0.2747	27.47%
Data	0.5567	55.67%
VAS	0.1686	16.86%
Total	1.0000	100.00%

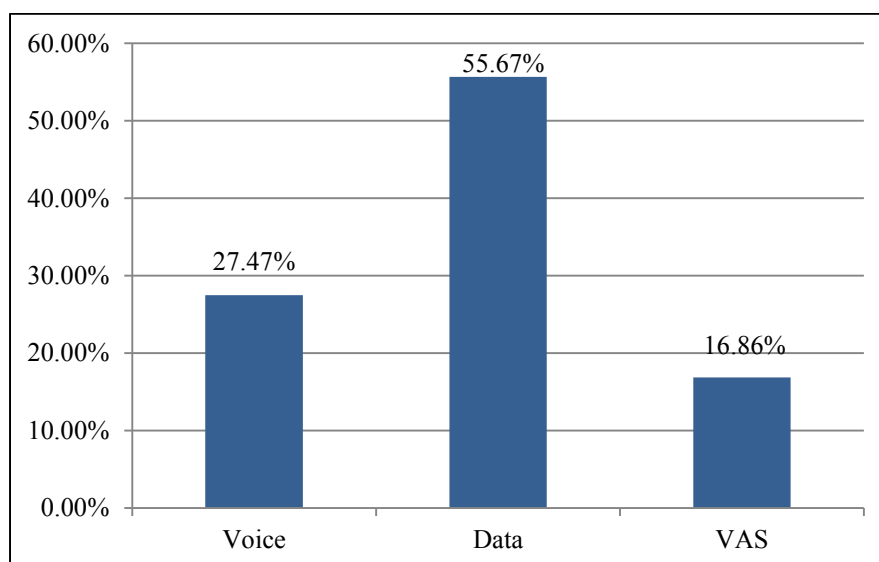


Figure 4:35 Graphical representation: global weights for alternatives – consolidated result of all experts’ judgment

From above tables and graphs, it is found that for successful adoption of 4G technology by telecommunication operators in Bangladesh, Technology is the most important factor with 62.39% global weight according to combined experts’ opinion. Based on the consolidation and analysis done in section 4.6.31 and section 4.7.11 it is found that, even when result is consolidated separately for both categories of experts (i.e. industry and independent), both industry experts and independent experts indicated Technology as the most important factor.

According to the combined opinion of all experts, in case of sub-factors, Network coverage and quality is the most important one with 32.14% global weight, followed by Technological up-gradation with 22.72%, Product-packages and pricing with 8.85% and

Advertising and branding with 8.22% global weight. Based on the consolidation and analysis done in section 4.6.31 and section 4.7.11 it is observed that, industry experts' combined opinion in case of sub-factors is similar with the final combined outcome except for the percentages. Combined opinion of independent experts indicated Technological up-gradation as the most important sub-factor followed by Network coverage and quality, Knowledge development and Advertising and branding.

According to combined experts' opinion, Data service is the most preferred than other two alternatives with 55.67% combined global weight followed by Voice Service (27.47%) and VAS (16.86%). Based on the consolidation and analysis done in section 4.6.31 and section 4.7.11 it is found that, even when result is consolidated separately for both categories of experts (i.e. industry and independent), both industry experts and independent experts indicated Data service as the most important factor.

The outcome of the research work contains much significance. It is found in a research conducted by GSMA (GSM Association) that Voice service still dominates the telecom market of the country [24]. In 2015, top three operators of the country (i.e. Grameenphone, Banglalink and Robi) who hold almost 90% of the market share of Bangladesh telecom market earned only around 10% of their revenue from Data services. This share was only 5% in 2014 [63]. Though Voice business is currently focused by operators, but this research indicates that focus need to be shifted to Data service for successful adoption of 4G technology. This finding is also supported by the fact that in 2015, top 3 operators' data revenue has increased 69% compared to 2014 [63].

4.9 General Discussion with Experts

Few open-ended general questions are asked to the experts as a part of the survey (as mentioned in section 3.3.4.3). The objective is to collect open idea from experts. The summary of the feedback is given below:

Regarding risks, barriers, difficulties etc. to implement and adopt 4G technology by telecom operators in Bangladesh, Expert 19, Expert 20, Expert 18 , Expert 5, Expert 12,

Expert 22, Expert 24, Expert 26, Expert 25, Expert 31, Expert 32 and Expert 38 mentioned about availability and price of 4G enabled handset.

Some experts mentioned about new investment required for 4G implementation and risk of recovery of investment as risk and difficulties. For example, Expert 2, Expert 5 and Expert 24 mentioned about high License fee and Bandwidth charge. Expert 1, Expert 2, Expert 6, Expert 22, Expert 33 and Expert 37 mentioned about investment by operators as a difficulty and Expert 39 mentioned “too much focus on quick recovery of investment” as a risk. While providing open opinion, Expert 32 stated “Return on investment should be considered”.

Some experts also identified that 4G knowledge-base of subscribers will be a challenge for operators. Regarding risks, barriers, difficulties for 4G implementation, Expert 17 mentioned about “Internet adoption by rural people”, Expert 21 stated “Arrange awareness development program in all locations of Bangladesh”; Expert 3 said “User adaptability of 4G over current 2G and 3G technology”. Also, Expert 16 stated “City based internet user” as a challenge. Expert 37 mentioned “Developing customers’ awareness about the benefits of this new technology and making 4G popular among them will be a challenge”. Expert 39 stated “Lack of knowledge to avail its benefits” as a difficulty.

Some experts also indicated cost associated with using 4G as challenge. Expert 31 mentioned “4G service charge” and, Expert 33 mentioned “Average income of consumers” and Expert 35 mentioned “cost” as a challenge, Expert mentioned “High price for availing the service” as a barrier. Expert 38 stated “Any new technology adoption depends on the socio-economic condition of a country. I think 4G proliferation in village area will be little bit difficult as people living in those region may not spend much to avail 4G.”

Regarding risks, barriers, difficulties etc., some experts highlighted few technical issues as well. Expert 32 stated “Complexity - as operators have to maintain 2G, 3G and 4G networks together for some years”. Expert 32 also mentioned about developing

infrastructure. Expert 36 stated “Up-gradation of existing 2G/3G equipment to 4G enabled equipment” and “Ensuring 4G network coverage with proper quality” as difficulties.

Experts are also requested to provide their open opinion about 4G technology implementation in Bangladesh.

Expert 6 mentioned that to fulfill the demand of developing the country as a “Digital Bangladesh” a must need is better network which may be ensured by 4G Technology.

Expert 25 said “4G seems to be a very promising generation of wireless communication that will change the people’s life”

Expert 3 stated “4G will give new area of experience, a new and advance window to look at the advanced world.”

Expert 22 said ““Implementing 4G will be a good investment because mobile operators (who can provide voice and data at the same time) will be the only source of wireless internet who can survive in Bangladesh”.

Expert 32 stated “Proper survey and preparation are essential” which strengthens the requirement of a concrete strategy.

Expert 33 commented “(4G) will be used mainly by young consumers. As the average age in Bangladesh is quite low, so there is a good prospect. Coverage will be a major issue.”

Expert 34 mentioned “Unlimited package should be available at competitive price compared to broadband network. Key area should be covered at the beginning of the implementation.”

Expert 36 commented “4G Technology implementation in Bangladesh will ensure better customer experience. Advanced communication technologies like 4G will help us to easily achieve our target of “Digital Bangladesh”

Expert 37 opined that “Many countries of the world have already implemented 4G and we need to join this team. Operators must ensure proper 4G service and speed. 4G will give customers a completely new type of communication experience.

Expert 38 stated “With the evolution of new technologies, 3G had been launch in Bangladesh in 2013. This 4G will be launched within a couple of years in mobile phone networks. Business, jobs and other activities will be increased and a large position of our people will be involved with this new technology and they will contribute to our economy in a significant way. Government will be able to provide their services to the common people in an easy way.”

Expert 39 mentioned “According to my personal view, at this moment, Bangladesh is fully ready to welcome 4G technology and make the most use of it. But as we have seen from previous experience that rural people are deprived from the benefits of such technology, while implementing 4G we have to bear it in mind and work accordingly.”

Expert 40 stated “To reach the goal of “Digital Bangladesh” we need to develop the ICT sector of the country. Ensuring new technologies like 4G for people of Bangladesh will be a big step towards that. 4G will also ensure faster establishment of better E-governance. Hence implementation of 4G in Bangladesh is very important.”

Independent experts are requested to provide open comments regarding considerations of environmental impact while adopting this new 4G technology.

Expert 32 mentioned that infrastructure buildup for 4G technology may create a new challenge to the environment. Expert 32 also stated “Impact of electromagnetic radiation on human health is believed to be a concern. Usage of 4G Technology may increase this radiation further.”

Expert 33 stated “If 4G becomes popular, people will dump old handsets. In Bangladesh still we do not have proper dumping/garbage handling units. Hence, it will create few problems for the environment.”

Expert 36 commented “Mobile tower generate radio frequency energy to provide telecommunication service. This radiation may have negative impact on environment and human health which is still under research. Researchers in many countries are working on this. But as a precaution, operators should consider this fact while adopting this new technology. Also, it is necessary to study what other countries have done to control this radiation impact.”

Expert 37 commented “It is known that antenna used to transmit telecom signals generate radiation which has some environment impact. But in this 21st century we cannot live without mobile phone. So we need to ensure that we can use 4G technology with as less environmental impact as possible. Operators should consider this while adopting 4G.”

Expert 38 mentioned “In a nutshell, I can say that the EMF will be increased in a large scale and health hazards might increase. But I think, till today, there is no scientific proof of any said hazard for EMF of telecommunication. As sites will increase, the environment will experience a bit more hazardous atmosphere. Thus, while adopting 4G technology, I think there will be some negative impacts on environment.”

Expert 39 mentioned “Although there is no concrete evidence that, radiation from GSM/UMTS BTSs cause harm to people and environment, still it is necessary to follow some safety procedures. In Bangladesh this monitoring routine is not executed properly. We must have strong monitoring ability in this regard.”

Expert 40 stated “The mobile towers are being established here and there, especially in city areas. City areas are congested with towers. Operators should consider this fact and must ensure that new towers are installed properly following global best practices and guidelines.” Expert 40 also stated “There are radiation impacts of mobile towers. Operators need to consider the safe limit of radiation and 4G technology accordingly implemented.”

4.10 Final Outcome of the Research Work: Summary of Findings

Following is the summary of findings of this research work:

Telecom consumers are not completely satisfied with the existing 2G and 3G technology available in Bangladesh. Experts opined that 4G technology will give consumers better mobile communication experience than existing 2G and 3G technology. They also opined that, introduction of 4G technology will be appreciated by customers.

Experts' opinion indicates that introduction of 4G technology in Bangladesh will bring success for countries' telecom operators i.e. it will be a positive business case, as well as launching of 4G technology will create positive impact on Socio-economic activities.

Above discussion supports the appropriateness to introduce 4G technology in Bangladesh in near future. Research indicates that tentative appropriate timeline to introduce 4G technology in Bangladesh is in between 2016 to 2017.

It is essential to find out the risks, barriers, difficulties etc. for successful adoption of 4G technology by telecom operators in Bangladesh.

Research shows that 4G enable handset is a major challenge for operators in Bangladesh to adopt 4G technology. Some experts particularly mentioned about availability and price of 4G enabled handset as a challenge in the general discussion of the survey.

In this research it is identified that pricing of 4G technology needs to be more attractive than existing 2G and 3G pricing and this can be a great risk for operators besides maintaining profit. Experts mentioned that 4G service charge that is price to avail the service is a major difficulty for operators to adopt 4G technology. As per experts' opinion considering the income level of consumers and socio-economic condition of the country, 4G proliferation can be difficult as people may not spend much to avail 4G, specially people living in rural areas. Experts also opined that new investment required for 4G implementation, high license fee and bandwidth charge etc. are major risks for operators. Return of investment is very crucial for any business and experts commented that much

focus on quick recovery of investment may put operators in a risky situation. A balanced pricing considering customers' affordability and operators' return of investment and profitability is one of the biggest challenge for successful adoption of 4G technology by telecom operators in Bangladesh.

In this study another challenge is identified which is providing more improvised after-sales customer service while adopting 4G technology. This is very crucial as customer service is very important for any business.

Research shows that customer knowledge base on 4G technology need to be improved while adopting 4G as this will be a new technology in Bangladesh and customers may lack in knowledge about the benefits and features of 4G. Experts opined that this is a difficulty for operators. As high-speed data is the major benefit of 4G over existing technologies, experts also mentioned that city based internet user and lack of interest to use internet by rural people will be challenge for 4G proliferation. In this regard experts opined that operators need to arrange campaigns, awareness development program throughout the country.

Research identifies that when 4G will be introduced, there will be continuous requirement of new type of products (packages) for customers to be offered by operators. Innovative product development is very crucial while adopting this new technology and this is another challenge for operators.

Regarding risks, barriers, difficulties etc., experts highlighted some particular technical issues also in the general discussion section of the survey. Maintaining 2G, 3G and 4G networks together during initial stages of 4G roll-out, developing 4G enable infrastructure, up-gradation of existing 2G and 3G equipment to 4G enabled equipment and ensuring 4G network coverage with proper quality are identified as difficulties by experts.

As 4G need to be implemented newly in the country, it is important to identify which geographical location operators should focus during initial stage of 4G technology roll-

out. Research shows that operators should focus on metropolitan areas during adoption of 4G technology.

As 2G and 3G will be running i.e. revenue-generating business for operators during 4G roll-out, it is important to find out what should be operators strategy regarding 2G and 3G technology that is what should be operators' business continuity approach. Experts opined that operators should equally focus on 4G and 3G and less on 2G as operators' business continuity approach during 4G technology adoption.

Regarding market acquisition approach, experts opined to choose "Moderately aggressive" market acquisition approach rather than extremely aggressive, but operators' approach should not be average (i.e. business-as-usual).

Identification of potential customer age-group is very important for any business. Research shows that both "18-29" and "30-49" age-groups need to be focused equally by telecom operators for 4G business.

It is also important to find out experts' opinion on probable negative impacts of growth of telecommunication technology throughout any country. Independent experts opined that as number of sites may increase while introducing 4G, environment may experience a bit more hazardous atmosphere. Operators are establishing telecom towers here and there in unplanned manner, especially in metropolitan and urban areas. These areas are congested with towers. Experts commented that telecom operators need to consider geographical location, congestion of sites, appropriate distance etc. while installing new sites during introduction of 4G technology. Operators must ensure that new towers are installed properly following global best practices and guidelines. Planned installation of telecom sites must be considered.

Equipment used for telecommunication service in telecom sites generate radio frequency energy (Electro Magnetic Field or EMF radiation) for signal transmission. This radiation may have negative impact on environment and human health. Experts opined that telecom operators need to consider environmental impact and impact of radiation from

mobile towers while adopting 4G technology. Experts also commented that in this 21st century it is almost impossible to live without advanced communication technologies hence it is required to ensure that 4G technology can be used with as less negative impact as possible. Experts suggested that operators should consider this fact while adopting 4G technology. They also suggested to follow some safety procedure upon studying what other countries have done to control such negative impact. Operators need to consider the safe limit of radiation. Regulators or government should monitor such impacts. Strong monitoring procedure need to develop by proper authority.

Now, following sub-sections (i.e. 4.10.1 and 4.10.2) discusses on the identification of critical factors and formulation of a strategic plan to successfully adopt 4G technology by telecommunication operators in Bangladesh. Section 4.11 discusses regarding development of an adoption model.

4.10.1 Critical factors to adopt 4G technology by telecom operators in Bangladesh

Based on results obtained in sections 4.6, 4.7 and 4.8, critical factors for successful adoption of 4G technology by telecom operators in Bangladesh are identified, which is one of the major outcomes of this research work. Following are these critical factors:

❑ **“Technology is the most critical factor”**

❑ Top 4 sub-factors are:

- Network coverage and quality
- Technological up-gradation
- Product-packages and pricing
- Advertising and branding

4.10.2 Strategic plan for successful adoption of 4G technology by telecom operators in Bangladesh

Based on results described throughout the chapter, a strategic plan is formulated for successful adoption of 4G technology by telecom operators in Bangladesh, which is one of the major outcomes of this research work.

This strategy is described in the following:

- ❑ Business should grow focusing on Data service.
- ❑ Voice and VAS business should be 2nd and 3rd priority respectively.
- ❑ Operational activities should focus on:
 - Network coverage and quality
 - Technological up-gradation
 - Product-packages and Pricing
 - Advertising and branding

Focus on Data business:

Operators in Bangladesh are still focused on Voice business but according to this research, focus need to be shifted to Data service for successful adoption of 4G technology by telecom operators in Bangladesh.

Network coverage and quality:

Telecom operators reaches to their customers through network coverage. Operators must ensure 4G network coverage throughout the country as quickly as possible upon launching. Side by side, they need to ensure the quality and smoothness of network as well so that customers are satisfied with 4G service. Operators need to properly handle complexity of maintaining 2G, 3G and 4G networks together during introduction of 4G technology so that customers receive smooth service.

Technological up-gradation:

Technological up-gradation must be done by operators with proper care. Infrastructure development for 4G technology and up-gradation of existing 2G and 3G equipment to 4G enabled equipment should be completed quickly and smoothly following appropriate procedures and all technical issues so that customers are not impacted and business is not hampered.

Product-packages and Pricing:

Pricing of 4G technology needs to be more attractive than existing 2G and 3G pricing. Also, operators need to offer exciting, attractive and innovative 4G related products (packages) for customers while introducing 4G. A balanced pricing strategy must be set by operators considering customers' attraction and affordability and operators' return of investment and profitability.

Advertising and branding:

Huge competition exist in telecom market of Bangladesh. Continuous advertising and branding is very crucial for all operators. Also, while launching 4G technology, operators must inform their customers about the benefits and new features of this new technology through proper advertising. Considering the competition, each individual operator needs to become a true 4G-branded operator through appropriate branding. High-speed data is the major benefit of 4G over existing technologies and also it is mentioned above that 4G business should grow focusing on Data service. But as a matter of fact, a huge portion of people of Bangladesh lives in rural areas who are not that much interested in using internet. In this regard operators need to ensure proper advertising of data service throughout the country.

This Strategic plan is presented with graphical view in Figure 4:36 which is the strategic model.

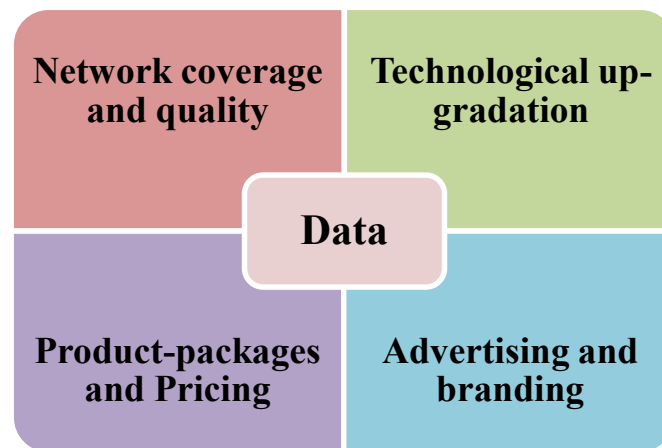


Figure 4:36 Strategic model for successful adoption of 4G technology by telecom operators in Bangladesh

For successful adoption of 4G technology, some other steps to be followed by operators which are also part of strategy. These are summarized below, which has also been developed based on the results described in this chapter.

- Business continuity approach: Operators should equally focus on 4G and 3G and less on 2G, as their business continuity approach during initial roll-out of 4G technology.
- Market acquisition approach: Operators' approach should be "Moderately aggressive" rather than extremely aggressive, but also it should not be average i.e. Business as usual.
- Major potential customer for 4G technology: both "18-29" and "30-49" age-groups need to be focused equally.
- Focus geographical location: During initial stage of 4G technology roll-out, major focus to be given on Metropolitan areas, whereas, secondary priority should be urban areas.

- Availability and price of 4G enable handset can be a challenge for 4G technology growth. Operators should take necessary steps to ensure 4G enable handsets are available to customers at an affordable price. Bundle-pack may be offered.
- Customer service is very crucial for any business. Existing after-sales customer service need to be more improvised while adopting 4G technology.
- Customer knowledge-base on 4G technology needs to be improved through campaign, nation-wide awareness development program, proper advertising etc. while adopting this new technology. Awareness need to be developed on features, advantages and applications of 4G technology.
- Telecom sites must be installed in planned manner. Operators should consider geographical location, congestion of sites, appropriate distance etc. while installing new sites during introduction of 4G technology. They must ensure that new towers are installed properly following global best practices and guidelines.
- Telecom operators need to consider impact of radiation generated from telecom equipment while adopting 4G technology. They should ensure that 4G technology can be used with as less negative impact as possible. Operators should consider the safe limit of radiation and should follow some safety procedure upon studying what other countries have done to control such negative impact. Operators should follow and ensure compliance to the national and international guidelines (whatever available) in this regard, for example, Bangladesh National Frequency Allocation Plan (NFAP), ICNIRP Guidelines etc.

4.11 Development of an Adoption Model

This section aims to develop a 4G Technology adoption model for telecommunication operators in Bangladesh, which is one of the expected outcome of this study.

The adoption model is developed based on the findings of the research work, expert opinion and with inspiration from the TOE (Technology, organization and environment) framework, which was developed by Tornatzky and Fleischer in 1990 [56].

4.11.1 The TOE Framework

The TOE i.e. the Technology, Organization and Environment context framework offers a convenient logical framework which can be used to study the adoption and integration of different types of technological innovation. It discusses different aspects of an organization's adoption and implementation of technological innovation [56]. This theory suggests that this adoption is influenced by technology development, organizational conditions, business and reconfiguration, and industry environment etc. [57]. This framework consists a solid theoretical base and consistent experiential support. Though specific factors defined in the TOE framework may vary across different studies, but this framework has huge potential of application in different technological change or innovation domains [56].

This framework classifies three aspects of an organization's context which impacts the process of adopting and implementing a technological change or innovation. These three aspects are: Technological context, Organizational context, and Environmental context.

Technological context refers to relevant technologies applicable to the organization. This may include practices and equipment internal to the organization, as well as available technologies external to the firm.

Organizational context refers to the descriptive measures about the organization like scope of its activities, organization size and structure. Environmental context is the domain in which organization conducts its business such as its industry, competitors and dealings with the government etc. [56].

The framework is represented elaborately in Figure 4:37.

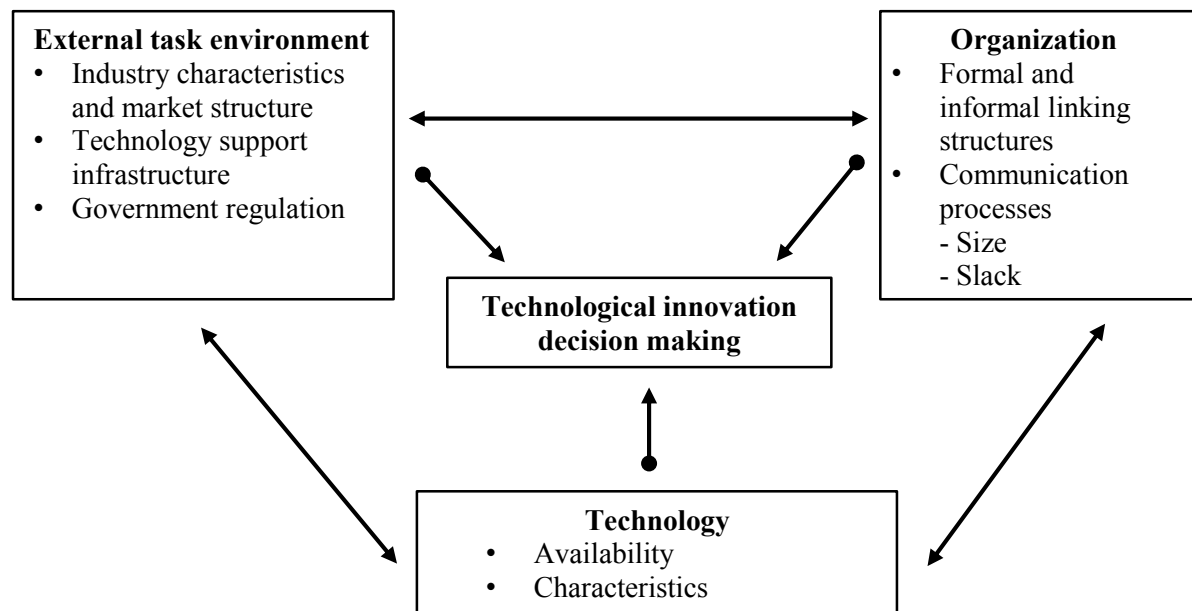


Figure 4:37 Technology, organization, and environment framework

4.11.2 4G Technology Adoption Model

The findings of the research work is taken into account and integrated to the TOE model to develop a novel model for 4G technology adoption by telecom operators in Bangladesh. This model is named as “4G Technology Adoption Model” and represented in Figure 4:38 and described in the following.

In this adoption model, Technological context is designed referring to relevant technological parameters applicable to the organization. From the findings of this research work, these parameters are improved network coverage and quality and proper technological up-gradation.

Organizational context refers to the descriptive measures about the organization. Organizational context of this adoption model is designed referring to focus on data service for business growth, concentration on metropolitan areas, equal focus on 4G and 3G and less on 2G for business continuity etc. Organization should also ensure improvised after-sales customer services and follow moderately aggressive market acquisition approach. Organization should set balanced pricing strategy considering

customers' attraction and affordability and operators' return of investment and profitability. Organization should develop innovative and exciting 4G related products (packages).

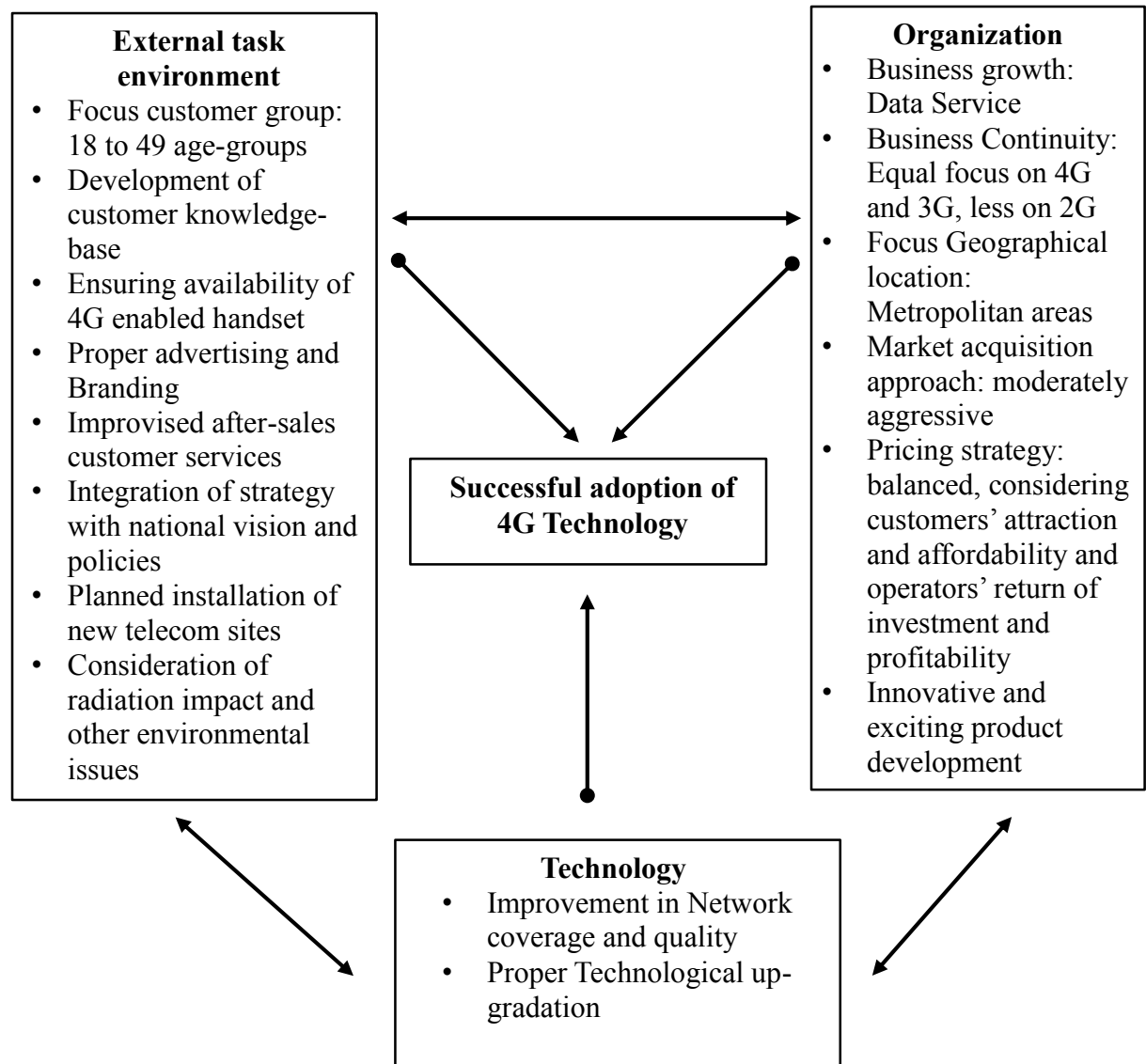


Figure 4:38 4G Technology Adoption Model

Environmental context is the domain in which organization conducts its business. Environmental context of the 4G Technology Adoption Model is designed referring to age-group 18 to 49 as focus customer group, requirement of development in customer knowledge-base, ensuring availability of 4G enabled handset in the market and proper

advertising and branding. Integration of strategy with national vision and policies, planned installation of new telecom sites, and consideration of radiation impact and other environmental issues are other crucial parts of environmental context.

4.12 Integration of Research Outcome with National Policies and Vision

The major outcome of the research is that operators should focus on Data service for 4G adoption. Information published by BTRC shows that as of December 2015, 95% of internet subscribers of Bangladesh uses data packages (Mobile internet) provided by mobile operators as internet source [58]. In numbers this is more than 5 crores people. This information ensures that operators have a big opportunity in Data business as voice business is already saturated and 4G technology will provide higher data rates.

Detail information are presented in Table 4-142.

Table 4-142 Internet subscribers in Bangladesh December, 2015

Internet medium	Subscribers (in Million)	Percentage (%) of total subscribers
Mobile Internet	51.453	95.1%
WiMAX	0.148	0.3%
ISP + PSTN	2.518	4.7%
Total	54.12	100.0%

Research outcome shows that, appropriate timeline to implement 4G technology in Bangladesh is in between 2016 to 2017. A recent statement made by the honorable State Minister for Post and Telecommunication of Bangladesh depicts that government also wants to launch 4G technology services as soon as possible, preferably within this year [59].

As per National Telecommunication Policy (NTP) of Bangladesh, Government's role will reduce as a service provider and private sector's role will increase [60]. Hence, it is clear that operators should take the major role while launching 4G technology in Bangladesh and for that, a concrete strategy is required for them.

NTP also states that, strategic vision of Bangladesh Government is to assist Universal Telephone Service throughout the country. These services includes (but not limited to) data services, access to internet, electronic mail, voice mail and video conferencing. These services to be ensured at reasonable cost and notable performance [60]. This national vision supports the outcome of the thesis that it will be appropriate to introduce 4G technology in Bangladesh in near future, because 4G technology will ensure achievement of these goals with its high-speed data. The thesis outcome also states that the major business focus needs to be Data service. Also to provide the service throughout the country, operators need to focus on country-wide network coverage and quality as well as technological up-gradation which are part of the strategy and developed adoption model.

“Access to New Technology” is a major objective of NTP. It is mentioned that government will encourage activities related to assist the absorption of new technology and to develop the facilities and services in telecommunication sector [60]. Hence it is clear that policy supports the introduction of any new technology like 4G. To ensure this “access”, operators should consider attractive product, packages and pricing for 4G technology, as well as 4G enabled handsets need to be made available to customers through bundle-packages. These are part of developed strategy and adoption model.

Users’ benefit is also focused in NTP. It is mentioned that government shall encourage transfer of new and latest technology for the users’ benefit. Another focus area of NTP is “Users Oriented Services”. It is stated that telecommunications services shall meet users’ demands and needs. Telecom networks shall be developed to be user-friendly. It is also mentioned in NTP that networks need to be equipped with modern technologies. All these statements are aligned with the thesis outcome considering the appropriateness of introducing 4G technology (latest technology for users’ benefit) and covered in formulated strategy i.e. technological up-gradation to be done. Proper advertising need to be done and customer knowledge-base also need to be improved through awareness so that they are aware of all benefits and services of 4G technology and can avail maximum benefit. These are also stated in the formulated strategy and part of adoption model.

National Frequency Allocation Plan (NFAP) of Bangladesh is the key to country's spectrum management. This plan identifies the distribution of spectrum among different stake-holders (government and non-government) as well as provides indication of the manner in which radio frequency spectrum should be utilized. NFAP reflects international agreements as well as national policies on the use of the radio spectrum to support the telecommunication sector [34].

Primary objectives of the NFAP includes “To allow the development of new services to meet customer and governmental demand for radio services” and “To stimulate technological innovation and competitiveness”. These statements are in-line with the thesis outcome (e.g. appropriateness of introducing 4G technology, innovative and attractive product development and development of customer knowledge-base regarding benefits of new technology). These are also stated in the formulated strategy and part of adoption model.

NFAP is developed based on ICNIRP (The International Commission on Non-Ionizing Radiation Protection) guideline to avoid any radiation impact associated with mobile communication network. ICNIRP is an independent scientific organization established in 1992. This commission investigates hazards that may be caused due to Non-Ionizing Radiation (NIR) and develops international guidelines on limits of exposure to non-ionizing radiations. This issue of radiation impact is also covered in the strategy formulated in this research work.

BTRC is the regulator of telecom operators of Bangladesh. This regulatory commission has some vision and objectives. The thesis outcome must also need to be aligned with BTRC vision and objectives.

Broad vision of BTRC is to facilitate connection towards the unconnected through quality telecommunication services by introducing new technologies and also at an affordable price [21]. This vision can be achieved properly with introducing 4G technology. Thesis outcome also states that 4G pricing need to be more attractive than existing technologies.

Some key objectives of BTRC are to encourage the orderly development of telecommunication system as well as to ensure the efficiency and capability of the national telecom system to compete in national and international spheres. BTRC will also focus on encouraging the introduction of new services. All these objectives indicate towards the necessity of introducing 4G technology in Bangladesh. Innovative product development is also captured in strategy which will ensure new services.

The development vision, mission, and goals of the Government of Bangladesh to achieve a prosperous country in the year 2021 are articulated in the “Perspective Plan of Bangladesh (2010-2021): Making Vision 2021 a Reality” [61]. The research outcomes need to be aligned with this perspective plan also.

One of the development priorities of this perspective plan is telecommunication sector. To build sound infrastructure in telecommunication sector is essential to achieve the vision of perspective plan.

Government’s target is to boost up investment in private sector and in the perspective plan, telecommunication sector is identified as one of the key areas where necessary investment climate need to be created. Government has prioritized telecommunication sector for foreign direct investment.

The internet is a gateway to large amount of information as well as it offers fast communication. Internet i.e. data usage is one of the focus areas of the perspective plan.

“The Vision 2021” articulated in the perspective plan constitutes a goal that is described as ‘Digital Bangladesh’ to address necessity of technological progress. As a whole, the ‘Digital Bangladesh’ idea is likely to assist the creation of a knowledge-based society, to move up in the development ladder as a country.

To arise as a ‘middle income country’, Bangladesh need an effective communication network. Development in telecommunication network is noted as a major requirement for

economic growth, because this sector plays a primary role in facilitating the distribution of information.

E-governance is a crucial weapon to achieve the goals of Perspective Plan. E-government means delivering the government services and information using electronic devices. E-governance will allow citizens to effectively communicate with government. Development of E-agriculture, E-medicine, E-learning and other knowledge areas through ICT is a crucial part of successful E-governance. One key strategic goals of establishing E-governance is Tele-centers or community e-centers with internet facilities in 100% centers by the year 2020 [61]. These can be achieved through nation-wide high-quality telecommunication network which can be provided by mobile operators. Standard and high-speed internet data service is also crucial for that, for which next-generation communication technology (i.e. 4G technology) is required.

To achieve the “Digital Bangladesh” goal, development in telecommunication sector is essential which is noticed in Perspective plan as well. Also it is noticed that latest technology needs to be made available to the people of Bangladesh to develop a knowledge-based society. Hence the vision of perspective plan supports the introduction of latest communication technology i.e. 4G.

'National Information and Communication Technology (ICT) Policy-2015' of Bangladesh was approved in the cabinet in early 2015 [64]. The visions of this policy is: expansion and multipurpose use of ICT to ensure transparency and accountability of the government, human resources development, ensure public services through public and private sector participation and achieve national development goals of becoming middle-income country by 2021 and developed country by 2041 [65].

The policy has 10 objectives, 54 strategic themes and 235 action items which will be implemented by different organizations under three phases- short-term goals are expected to be reached by 2016, mid-term goals by 2018 and long-term ones by 2021 [65]. Policy structure is shown in Figure 4:39.

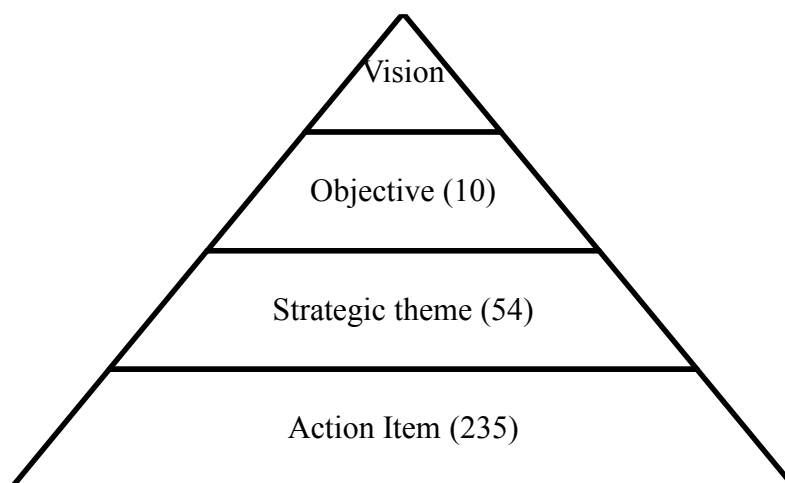


Figure 4:39 Policy Structure

In this policy, telecommunication is given proper importance through connection to the objectives and themes. Upon studying the ICT Policy, research outcome is integrated with it as well.

One major objective of this policy is “Universal Access” i.e. ensuring telecommunication technology and internet service for everyone following National Telecommunication Policy. Mobile operators are a crucial stakeholder to achieve this target as they can provide voice and data services at the same time and has a nationwide setup already.

Another objective of the policy is “Strengthening Exports” i.e. ensuring development of Software industry, IT Services, E-commerce, E-business and IT industry to meet the demand of internal and external market, to increase income from foreign sources and to attract foreign investment.

“Supports to ICTs” is another objective of ICT policy where two key strategic themes have been identified as – decentralization of ICT development activities outside the capital city and increasing the availability and dependability of internet.

Maximum and innovative application of ICT to ensure quality Healthcare is another objective of the ICT Policy. Telemedicine is a key point to achieve this objective.

Application of ICT for Environment, Climate & Disaster Management is another objective of the Policy. To save citizens from natural disasters by applying ICT-based disaster management technology is a key theme to achieve this objective.

Another objective of the ICT policy is to apply ICT in all aspects of national economy to achieve higher Productivity. To encourage E-commerce, E-payment etc. to increase productivity is a major strategic theme to achieve this objective.

All the above objectives of ICT Policy supports the requirement of nation-wide high-quality telecommunication network and high-speed internet data service through which all concerned organizations and people can easily communicate and enjoy the benefit of ICT. Hence operators should focus on providing next-generation communication technology (i.e. 4G technology) as well as Data services should be prioritized. Operators should also consider sufficient improvement of network coverage and quality and proper technological up-gradation. Innovative products and pricing need to be developed and proper advertising to be done to attract and aware people to use telecommunication services for successful achievement of the ICT Policy objectives. All these issues have been covered in the formulated strategy and developed model.

All above discussions depict that the outcome of this research work is completely aligned with national policies and vision.

4.13 Author's Opinion

In Chapter 2 applications and advantages of 4G technology is discussed in details. Also, a brief overview on world-wide status of 4G implementation and forecasting is given. Based on that discussion, author is hence convinced that Bangladesh should also join the 4G-run as soon as possible.

With introduction of 3G services, the telecommunication sector of Bangladesh has moved from voice era to data era. With the arrival of 3G technology number of mobile phone data users is increasing fast. Bangladesh is one of the fastest growing markets in the

world in terms of communication outreach considering the spread of mobile internet [50]. Information provided in Table 4-142 depicts the importance of Data business for telecom operators as 95% of internet users of Bangladesh uses mobile internet. Author thinks that Data service will be more important than ever in future due to the development of various mobile software applications, mobile online games and other similar mobile services. Hence, author supports the main outcome of the thesis that Data services should be prime business focus for operators while adopting 4G technology. This mobile internet can be a critical enabler of “Digital Bangladesh” and a crucial weapon to establish E-governance.

Network coverage is the heart of telecom business for operators. Operators’ provide telecom services to customers through their network. Author suggests that network coverage and quality need to be given top-most priority as well as proper technological up-gradation need to be ensured for smooth 4G technology service. As research outcome shows that customers of Bangladesh are not satisfied with existing services, author suggests that operators must ensure this dissatisfaction does not continue in case of 4G service also. Government bodies like BTRC should monitor whether operators are providing proper 4G service as per standard.

Investment associated with 4G technology implementation is very crucial for operators, as well as customers’ expectation and affordability to avail 4G service need to be considered. Hence, balanced pricing structure is a big factor here but as discussed in Chapter 2, operators are facing many challenges regarding various taxes and duty as well as license fee, spectrum charge etc. Government should consider the rates of these taxes and duty for the growth of telecom sector.

Hazardous impact of telecommunication service is discussed with importance in this study. But in this modern world it is quite impossible to live without faster communication technologies. Measures to avoid such impacts are included in the strategy formulated for operators. Author also suggests that government should monitor whether operators are following proper guidelines. If required, government should update existing

guidelines and develop new one where not available. Operators should proactively help government in this regard.

Introduction of 4G technology will be a huge event for country's telecom sector. Management of technology is very crucial here for successful adoption of 4G. Operators as well as regulators along with government need to work jointly in this regard. Proper collaboration among all stake-holders is very important to get the highest benefit from telecom sector. To develop this sector government should ensure a friendly environment as well as operators also need to implement appropriate strategy while introducing any new technology like 4G.

4.14 Chapter Summary

In this chapter, detail analysis of the primary data collected through survey is provided. All experts' opinion are summarized and consolidated result is discussed and analyzed in details. In Chapter 2, appropriateness of introducing 4G technology in Bangladesh is discussed though literature review and in this chapter outcome of the research work in this issue is discussed. The major outcomes of this study work which are identification of critical factors, formulation of a strategic plan and development of a model for successful adoption of 4G technology by telecommunication operators in Bangladesh are presented in this chapter.

Finally the research outcomes is integrated with national policies and vision. Author's opinion is also provided in this chapter.

Next, Chapter 5 provides the conclusion to this research work. A general discussion is done on the overall research work. Contributions of this study are discussed. A conclusion of this research work is provided in that chapter along with scope of future work.

CHAPTER 5

CONCLUSION

5.1 Introduction

In the previous chapter detail analysis of the primary data collected through survey is presented. Final results and discussion are the main contents of previous chapter.

In this last chapter of the thesis, a general discussion is done on the overall research work. Contribution of this study is provided. A conclusion of this thesis is drawn. In addition, scope of future work is also discussed.

5.2 General Discussion: Summary of the Thesis

This thesis began by presenting the problem statement based on which this study work is conducted. In a nutshell, launching of 4G technology will be very crucial for country's telecom market. Successful adoption of this new technology is very important. For all operators, concrete strategy and appropriate model are very important to adopt 4G technology successfully.

At first the outline of research methodology is drawn which includes working strategy finalization i.e. research model development, literature review, preparation for survey, preparation and finalization of questionnaire, conduction of survey, data collection (primary and secondary data), analysis of collected data and decision making.

A literature review is carried out to provide an overview on the telecommunications technologies. Several technologies e.g. 1G, 2G, 3G and 4G are discussed. Furthermore, present scenario of the telecommunication sector in Bangladesh is discussed from different perspective. Governance of telecom sector, challenges in this sector, profile and market share of telecom operators in Bangladesh, spectrum allocation, contribution of telecommunication sector to the economy of the country etc. are also discussed. In

addition, a literature review is done on appropriateness of introducing 4G technology in Bangladesh. Advantages and applications of 4G technology is discussed in details along with world-wide current deployment of this technology.

Then, the study moved forward towards the experimentation step. In this research, Analytic Hierarchy process (AHP) is used as a research tool for experimental analysis and decision making. AHP has widespread application in decision-making problems which involves multiple criteria of many levels. AHP has the ability to construct complex, multi-person, multi-attribute, and multi-period problem hierarchically. AHP is very useful in case arriving at an agreed decision where several decision-makers with different conflicting objectives are involved.

Primary data are collected from a survey using questionnaire which is performed by the ways of written survey. Questionnaire contained both closed-ended questions (e.g. questions with multiple options and AHP based pair-wise comparison questionnaire) and open-ended questions (to collect experts' open opinion). The survey is conducted among selected experts in telecommunication domain of Bangladesh. Experts selected for this research are divided into two categories– industry experts and independent experts. 30 experts are selected as industry experts from telecommunication operators, network equipment vendors and local services providers (LSPs) of Bangladesh. 10 experts are selected as independent experts from universities and regulatory commission i.e. BTRC. Hence total number of experts is 40 i.e. sample size is 40 for this research work.

Secondary data are collected from papers, journals, related studies, documents, books, internet and newspaper review and other sources of information.

After data collection, primary and secondary data are compiled and accumulated for analysis. For data analysis, AHP online application software (AHP-OS) is used which is a web-based analysis tool which helps rational decision making based on Analytic Hierarchy Process (AHP). Microsoft Excel spreadsheet is also used for various calculations.

Following are the outcomes of this research work:

- i) Research identifies that telecom consumers are not completely satisfied with the existing 2G and 3G technology available in Bangladesh. Experts opined that 4G technology will give consumers better mobile communication experience than existing 2G and 3G technology. Experts' opinion indicated that, launching of 4G technology will create positive impact on Socio-economic activities. This discussion establishes the appropriateness to introduce 4G technology in Bangladesh in near future.
- ii) It is found in the research that for successful adoption of 4G technology by telecommunication operators in Bangladesh, Technology is the most important factor with 62.39% global weight according to combined experts' opinion. In case of sub-factors, Network coverage and quality is the most important one with 32.14% global weight, followed by Technological up-gradation with 22.72%, Product-packages and pricing with 8.85% and Advertising and branding with 8.22% global weight. Based on results obtained, critical factors for successful adoption of 4G technology by telecom operators in Bangladesh are identified. Following are these critical factors:
 - Technology is the most critical factor
 - Top 4 sub-factors are:
 - Network coverage and quality
 - Technological up-gradation
 - Product-packages and pricing
 - Advertising and branding
- iii) It is found in the research that for successful adoption of 4G technology by telecommunication operators in Bangladesh, Data service is the most preferred than other two alternatives with 55.67% combined global weight followed by Voice service (27.47%) and VAS (16.86%). Though operators in Bangladesh are still focused on Voice business but according to this research, focus need to be shifted to Data service.

- iv) Research outcome indicates that operators must ensure 4G network coverage throughout the country maintaining proper quality as quickly as possible upon launching. Operators need to properly handle complexity of maintaining 2G, 3G and 4G networks together during introduction of 4G technology so that customers receive smooth service.
- v) Technological up-gradation is very crucial and must be done by operators with proper care. Infrastructure development for 4G technology and up-gradation of existing 2G and 3G equipment to 4G enabled equipment should be completed quickly and smoothly so that customers are not impacted and business is not hampered.
- vi) Appropriate advertising and branding is very crucial for all operators while launching 4G technology, operators must inform their customers about the benefits and new features of this new technology through proper advertising. Considering the competition, each individual operator needs to become a true 4G-branded operator through appropriate branding. Customer knowledge base on 4G technology need to be improved while adopting 4G as this will be a new technology in Bangladesh and customers may lack in knowledge about the benefits and features of 4G. In this regard operators need to arrange campaigns, awareness development program throughout the country A huge portion of people of Bangladesh lives in rural areas who are not that much interested in using internet. Hence, operators need to ensure proper advertising of data service throughout the country.
- vii) Research shows that availability and price of 4G enable handset can be a challenge for 4G technology growth in Bangladesh. Operators should take necessary steps to ensure 4G enable handsets are available to customers at an affordable price.
- viii) It is also identified in the research that pricing of 4G technology needs to be more attractive than existing 2G and 3G pricing. Considering the income level of consumers and socio-economic condition of the country, people may not spend much to avail 4G. New investment required for 4G implementation, high license fee and bandwidth charge etc. are major risks for operators. Hence, operators need to offer

exciting, attractive and innovative 4G related products (packages) for customers while introducing 4G. A balanced pricing considering customers' affordability and operators' return of investment and profitability is one of the most biggest challenge for successful adoption of 4G technology by telecom operators in Bangladesh.

- ix) Research also shows that operators should equally focus on 4G and 3G and less on 2G, as their business continuity approach during initial roll-out of 4G technology. They should follow "Moderately aggressive" approach for market acquisition. Customers falling in age limit "18-49" should be focused as potential customer for 4G technology. During initial stage of 4G technology roll-out, major focus to be given on metropolitan areas. Existing after-sales customer service need to be more improvised while adopting 4G technology.
- x) Telecom sites must be installed in planned manner. Operators must ensure that new towers are installed properly following global best practices and guidelines. Operators need to consider impact of radiation generated from telecom equipment while adopting 4G technology. They should ensure that 4G technology can be used with as less negative impact as possible. They should follow and ensure compliance to the national and international guidelines (whatever available) in this regard. Government should also monitor such issues.
- xi) Based on the results obtained through the research work, a strategic plan is formulated for successful adoption of 4G technology by telecom operators in Bangladesh. A model to successfully adopt 4G technology is also developed based on the findings of the research work, expert opinion and with inspiration from the TOE (Technology, organization and environment) framework which was developed by Tornatzky and Fleischer. This model is named as "4G Technology Adoption Model". Research outcome is integrated with the national policies and vision.

5.3 Contributions of the Thesis

Contributions of this thesis are presented in the following:

- i) The material presented in this thesis report inform mobile operators as well as government and other concerned on understanding the appropriateness of introducing of 4G technology in Bangladesh in near future.
- ii) The thorough process of the research work undertaken by this author leads to identify critical factors to adopt 4G technology by telecom operators in Bangladesh.
- iii) Potential environmental impacts of growth of telecommunication technology are identified and highlighted in this research work. Operators and government both are suggested plans to avoid such negative impacts while adopting 4G technology.
- iv) Through this research, a concrete strategic plan including steps to adopt 4G technology by telecom operators in Bangladesh is formulated.
- v) Based on the research, a model is also developed for successful adoption of 4G technology. The model is named as “4G Technology Adoption Model”.
- vi) Finally, the research outcomes i.e. the formulated strategic plan and developed adoption model are integrated with national policies and vision.
- vii) Findings of this research work can be applied by concerned organizations and authorities in telecommunication domain of Bangladesh for successful adoption of 4G technology.

5.4 Concluding Remarks

Telecommunication sector of Bangladesh has lot of potential even considering some challenges. In this research, it is found that 4G technology is appropriate for Bangladesh and need to be launched in near future. Thesis outcome also states that customers will

welcome the launching of 4G technology. Introduction of new technology will create new prospects for the operators. Operators need to play a vital role in this case. They will have the opportunity to contribute in country's growth and target to achieve "Vision 2021" with successful adoption of 4G technology. Proper management of technology is very crucial in this case and to assist concerned entities, critical factors for successful adoption of 4G technology are identified, a strategic plan is formulated and an adoption model is also developed in this research work. The research outcome is also aligned with national policies and vision. Some suggestion is also made to the government. Not only operators but all concerned organizations and authorities in telecommunication domain of Bangladesh may review this thesis paper for successful adoption of 4G technology.

5.5 Scope of Future Work

International mobile telecommunication service is an interesting and fast-moving area of academic research. As stated at the beginning of this thesis, telecommunication industry of Bangladesh is rapidly moving towards a crucial point with the introduction of 3G and introduction of 4G technology will fasten this movement. A lot of opportunities will be open for telecom operators in Bangladesh with the introduction of 4G technology. It will be interesting to watch how operators actually adopt this new technology in reality. This may be studied during the initial phase of 4G technology launching. Also, the actual impact of the critical factors identified in this research work may be studied. Researchers may also study how operators and government deal with various harmful impacts of growth telecommunication technology like radiation impact and unplanned installation of sites. Balanced pricing structure for 4G services considering different aspects can be another interesting area of future research. In future it may also be analyzed that after launching, how customers respond to 4G technology as well as how this new technology actually impacts on operators' business and how this technology is managed by concerned entities in real life. It is also expected that many other interesting areas of research work will be opened for country's researchers with the introduction of 4G technology in Bangladesh.

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APPENDIX I

Questionnaire Used for Survey

[Questionnaire supplied to industry experts]

Questionnaire

(The objective of this survey is to collect data for academic purpose under a reputed government university of Bangladesh. The research area is the telecommunication industry of the country. Collected data are fully confidential and will be used only for academic purpose. Participants' information will NOT be disclosed elsewhere. Thanks in advance you for your cooperation.)

Participant is a representative from	☐ Telecom operator	☐ Network Equipment Vendor	☐ Local Service Provider
Do you have decision making or recommendation making authorization in your organization	☐ Yes	☐ No	
Name			
Organization			
Experience in Telecom industry (Year)			
Last achieved educational degree			
Contact : Mobile number			
Email address: (optional)			

Part 01: General questionnaire: objective

1. Do you think telecom consumers are satisfied with the 2G & 3G services available in Bangladesh?

☐ Strongly disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly agree
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2. Do you think that introduction of 4G technology will give consumers better mobile communication experience than existing 2G / 3G technology :

☐ Strongly disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly agree
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3. Do you agree that introduction of 4G technology in Bangladesh will bring success (i.e. positive business case) for countries' telecommunication operators?

☐ Strongly disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly agree
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4. When do you think it will be appropriate to introduce 4G Technology in Bangladesh:

☐ 0 – 1 year	☐ 1 – 2 years	☐ 2- 3 years	☐ 3 – 4 years	☐ Later than 4 years
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5. Do you think availability of 4G enable handset will be a challenge for 4G growth?

☐ Yes	☐ No
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6. Do you think customers will welcome the introduction of 4G Technology ?

☐	Yes	☐	No
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7. During initial stage of 4G technology roll-out, which geographical location do you think operators should focus?

☐	Metropolitan areas	☐	Urban areas	☐	Sub-Urban areas	☐	Rural areas	☐	All over the country
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8. As 2G and 3G will be running i.e. revenue generating business for operators during 4G roll-out, which of the below should be most appropriate approach for operators?

☐	All focus on 4G – no focus on 3G 2G	☐	Major focus on 4G - little focus on 3G&2G	☐	Equally major focus on 4G & 3G – less focus on 2G	☐	Equal focus on 4G, 3G, 2G
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9. What will be the most appropriate market acquisition approach for 4G adoption:

☐	Extremely Aggressive & Innovative	☐	Moderately aggressive	☐	Business as usual (BAU)	☐	Slower than BAU
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10. Which age-group do you think will be major potential customer for 4G technology:

☐	18 - 29	☐	30 - 49	☐	49 – 64	☐	65+
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11. Do you agree that introduction of 4G technology will create positive impact on socio-economic activities in the country?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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12. Do you think 4G pricing need to be more attractive than existing 2G& 3G pricing ?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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13. Do you think existing after-sales customer service need to be more improvised while adopting 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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14. Do you think customer knowledge base on 4G technology need to be improved through campaign while adopting this new technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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15. Do you think innovative product development is crucial while adopting this new 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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Part 02: Preference-based pair-wise questionnaire

Factor: Technology (F1)	Factor: Sales and Marketing (F2)	Factor: Ripple effect (F3)
Sub-factor: • Network coverage & quality (A1), • Technological up-gradation (A2), • Knowledge development (A3)	Sub-factors: • Advertising & branding (B1) • Customer classification and analysis (B2) • Product, Packages and Pricing (B3) • After-sales customer service (B4)	Sub-factors: • Social impact (C1), • Economic impact (C2) • Customer response (C3)
Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)	Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)	Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)

Judgments of preference	Numerical Rating
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Based on above, please fill up below pair-wise comparison table

SI	Pair-wise Comparison table		On a scale from 1 to 9, to what extent your answer is more preferred than the other one									
	To adopt 4G technology by Bangladeshi Telecom operators, which factor is more preferable: (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
1	Technology (F1)	Sales & Marketing (F2)	1	2	3	4	5	6	7	8	9	
2	Technology (F1)	Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	
3	Sales & Marketing (F2)	Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	
	With respect to the factor Technology (F1), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
4	Network coverage & quality, (F1A1)	Technological up-gradation, (F1A2)	1	2	3	4	5	6	7	8	9	
5	Network coverage & quality, (F1A1)	Knowledge development, (F1A3)	1	2	3	4	5	6	7	8	9	
6	Technological up-gradation, (F1A2)	Knowledge development, (F1A3)	1	2	3	4	5	6	7	8	9	

	With respect to the factor Sales & Marketing (F2), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
7	Advertising & branding, (F2B1)	Customer classification & analysis, (F2B2)	1	2	3	4	5	6	7	8	9	
8	Advertising & branding, (F2B1)	Product, Packages & Pricing (F2B3)	1	2	3	4	5	6	7	8	9	
9	Advertising & branding, (F2B1)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
10	Customer classification & analysis (F2B2)	Product, Packages & Pricing (F2B3)	1	2	3	4	5	6	7	8	9	
11	Customer classification & analysis (F2B2)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
12	Product, Packages & Pricing (F2B3)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
	With respect to the factor Ripple effect (F3), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
13	Social Impact, (F3C1)	Economic impact (F3C2)	1	2	3	4	5	6	7	8	9	
14	Social Impact, (F3C1)	Customer response (F3C3)	1	2	3	4	5	6	7	8	9	
15	Economic impact (F3C2)	Customer response (F3C3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Network coverage & quality (F1A1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
16	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
17	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
18	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Technological up-gradation (F1A2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
19	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
20	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
21	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Knowledge development (F1A3), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
22	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
23	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
24	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Advertising & branding (F2B1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
25	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
26	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
27	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Customer classification & analysis (F2B2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
28	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
29	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
30	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Product, Packages & Pricing (F2B3), which alternative is more preferable? (compared to each other - in each pair):		If Equal	If not equal, how much more preferred?								
31	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
32	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
33	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor After-sales customer service (F2B4), which alternative is more preferable? (compared to each other - in each pair):		If Equal	If not equal, how much more preferred?								
34	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
35	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
36	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Social Impact (F3C1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
37	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
38	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
39	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Economic impact (F3C2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
40	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
41	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
42	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Customer response (F3C3), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
42	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
44	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
45	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

Part 03: General questionnaire: subjective

1. Please mention some risks, barriers, difficulties etc to implement and adopt 4G technology.
2. Please give your open opinion about 4G technology implementation in Bangladesh.

Thank You for Participating on the Research

[Questionnaire supplied to independent experts]

Questionnaire

(The objective of this survey is to collect data for academic purpose under a reputed government university of Bangladesh. The research area is the telecommunication industry of the country. Collected data are fully confidential and will be used only for academic purpose. Participants' information will NOT be disclosed elsewhere. Thanks in advance you for your cooperation.)

Name	
Organization	
Designation	
Contact : Mobile number	
Email address: (optional)	

Part 01: General questionnaire: objective

1. Do you think telecom consumers are satisfied with the 2G & 3G services available in Bangladesh?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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2. Do you think that introduction of 4G technology will give consumers better mobile communication experience than existing 2G / 3G technology :

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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3. Do you agree that introduction of 4G technology in Bangladesh will bring success (i.e. positive business case) for countries' telecommunication operators?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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4. When do you think it will be appropriate to introduce 4G Technology in Bangladesh:

☐	0 – 1 year	☐	1 – 2 years	☐	2- 3 years	☐	3 – 4 years	☐	Later than 4 years
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5. Do you think availability of 4G enable handset will be a challenge for 4G growth?

☐	Yes	☐	No
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6. Do you think customers will welcome the introduction of 4G Technology ?

☐	Yes	☐	No
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7. During initial stage of 4G technology roll-out, which geographical location do you think operators should focus?

☐	Metropolitan areas	☐	Urban areas	☐	Sub-Urban areas	☐	Rural areas	☐	All over the country
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8. As 2G and 3G will be running i.e. revenue generating business for operators during 4G roll-out, which of the below should be most appropriate approach for operators?

☐	All focus on 4G – no focus on 3G 2G	☐	Major focus on 4G - little focus on 3G&2G	☐	Equally major focus on 4G & 3G – less focus on 2G	☐	Equal focus on 4G, 3G, 2G
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9. What will be the most appropriate market acquisition approach for 4G adoption:

☐	Extremely Aggressive & Innovative	☐	Moderately aggressive	☐	Business as usual (BAU)	☐	Slower than BAU
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10. Which age-group do you think will be major potential customer for 4G technology:

☐	18 - 29	☐	30 - 49	☐	49 – 64	☐	65+	☐
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11. Do you agree that introduction of 4G technology will create positive impact on socio-economic activities in the country?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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12. Do you think 4G pricing need to be more attractive than existing 2G& 3G pricing ?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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13. Do you think existing after-sales customer service need to be more improvised while adopting 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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14. Do you think customer knowledge base on 4G technology need to be improved through campaign while adopting this new technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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15. Do you think innovative product development is crucial while adopting this new 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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16. Do you think telecom operators need to consider geographical location, congestion of sites, appropriate distance etc. while installing new sites during introduction of this new 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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17. Do you think telecom operators need to consider environmental impact and levels of Electro Magnetic Field (EMF) Radiation from mobile towers while adopting this new 4G technology?

☐	Strongly disagree	☐	Disagree	☐	Neutral	☐	Agree	☐	Strongly agree
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Part 02: Preference-based pair-wise questionnaire

Factor: Technology (F1)	Factor: Sales and Marketing (F2)	Factor: Ripple effect (F3)
Sub-factor: • Network coverage & quality (A1), • Technological up-gradation (A2), • Knowledge development (A3)	Sub-factors: • Advertising & branding (B1) • Customer classification and analysis (B2) • Product, Packages and Pricing (B3) • After-sales customer service (B4)	Sub-factors: • Social impact (C1), • Economic impact (C2) • Customer response (C3)
Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)	Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)	Alternatives: ➤ Voice service (S1) ➤ Data Service (S2) ➤ Value Added Services (S3)

Judgments of preference	Numerical Rating
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Based on above, please fill up below pair-wise comparison table

SI	Pair-wise Comparison table		On a scale from 1 to 9, to what extent your answer is more preferred than the other one									
	To adopt 4G technology by Bangladeshi Telecom operators, which factor is more preferable: (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
1	Technology (F1)	Sales & Marketing (F2)	1	2	3	4	5	6	7	8	9	
2	Technology (F1)	Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	
3	Sales & Marketing (F2)	Ripple Effect (F3)	1	2	3	4	5	6	7	8	9	
	With respect to the factor Technology (F1), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
4	Network coverage & quality, (F1A1)	Technological up-gradation, (F1A2)	1	2	3	4	5	6	7	8	9	
5	Network coverage & quality, (F1A1)	Knowledge development, (F1A3)	1	2	3	4	5	6	7	8	9	
6	Technological up-gradation, (F1A2)	Knowledge development, (F1A3)	1	2	3	4	5	6	7	8	9	

	With respect to the factor Sales & Marketing (F2), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
7	Advertising & branding, (F2B1)	Customer classification & analysis, (F2B2)	1	2	3	4	5	6	7	8	9	
8	Advertising & branding, (F2B1)	Product, Packages & Pricing (F2B3)	1	2	3	4	5	6	7	8	9	
9	Advertising & branding, (F2B1)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
10	Customer classification & analysis (F2B2)	Product, Packages & Pricing (F2B3)	1	2	3	4	5	6	7	8	9	
11	Customer classification & analysis (F2B2)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
12	Product, Packages & Pricing (F2B3)	After-sales customer service (F2B4)	1	2	3	4	5	6	7	8	9	
	With respect to the factor Ripple effect (F3), which sub-factor is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
13	Social Impact, (F3C1)	Economic impact (F3C2)	1	2	3	4	5	6	7	8	9	
14	Social Impact, (F3C1)	Customer response (F3C3)	1	2	3	4	5	6	7	8	9	
15	Economic impact (F3C2)	Customer response (F3C3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Network coverage & quality (F1A1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
16	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
17	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
18	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Technological up-gradation (F1A2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
19	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
20	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
21	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Knowledge development (F1A3), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
22	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
23	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
24	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Advertising & branding (F2B1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
25	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
26	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
27	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Customer classification & analysis (F2B2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
28	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
29	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
30	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Product, Packages & Pricing (F2B3), which alternative is more preferable? (compared to each other - in each pair):		If Equal	If not equal, how much more preferred?								
31	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
32	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
33	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor After-sales customer service (F2B4), which alternative is more preferable? (compared to each other - in each pair):		If Equal	If not equal, how much more preferred?								
34	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
35	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
36	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Social Impact (F3C1), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
37	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
38	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
39	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
	With respect to the Sub-factor Economic impact (F3C2), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
40	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
41	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
42	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

	With respect to the Sub-factor Customer response (F3C3), which alternative is more preferable? (compared to each other - in each pair)		If Equal	If not equal, how much more preferred?								
42	Voice service (S1)	Data Service (S2)	1	2	3	4	5	6	7	8	9	
44	Voice service (S1)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	
45	Data Service (S2)	Value Added Services (S3)	1	2	3	4	5	6	7	8	9	

Part 03: General questionnaire: subjective

1. Please mention some risks, barriers, difficulties etc to implement and adopt 4G technology.
2. Please give your open opinion about 4G technology implementation in Bangladesh.
3. Please provide your open comments regarding considerations of environmental impact while adopting this new 4G technology?

Thank You for Participating on the Research

APPENDIX II

Demographic Data of the Experts

Demographic data of the industry experts:

Identification	Organization Type	Experience (Years)	Last achieved degree
Expert 1	Telecom Operator	5	Bachelors
Expert 2	Telecom Operator	10	Masters
Expert 3	Telecom Operator	8	Masters
Expert 4	Telecom Operator	11	Masters
Expert 5	Telecom Operator	10	Masters
Expert 6	Telecom Operator	7	Bachelors
Expert 7	Telecom Operator	10	Bachelors
Expert 8	Telecom Operator	5	Bachelors
Expert 9	Telecom Operator	5	Bachelors
Expert 10	Equipment vendor	10	Masters
Expert 11	Equipment vendor	7	Masters
Expert 12	Equipment vendor	18	Bachelors
Expert 13	Equipment vendor	10	Masters
Expert 14	Equipment vendor	15	Bachelors
Expert 15	Telecom Operator	10.5	Bachelors
Expert 16	Telecom Operator	15	Masters
Expert 17	Telecom Operator	17	Bachelors
Expert 18	Local Service Provider	5	Masters
Expert 19	Local Service Provider	5	Bachelors
Expert 20	Local Service Provider	9	Bachelors
Expert 21	Local Service Provider	8	Bachelors
Expert 22	Local Service Provider	9.5	Bachelors
Expert 23	Local Service Provider	15	Masters
Expert 24	Local Service Provider	16	Bachelors
Expert 25	Local Service Provider	9.5	Bachelors
Expert 26	Local Service Provider	8	Bachelors
Expert 27	Telecom Operator	8	Bachelors
Expert 28	Local Service Provider	5	Bachelors
Expert 29	Telecom Operator	7	Bachelors
Expert 30	Local Service Provider	15	Bachelors

Demographic data of the independent experts:

Identification	Organization Type	Designation
Expert 31	University	Associate Professor
Expert 32	University	Assistant Professor
Expert 33	University	Associate Professor
Expert 34	University	Assistant Professor
Expert 35	University	Assistant Professor
Expert 36	Regulatory Commission	Senior Assistant Director
Expert 37	Regulatory Commission	Senior Assistant Director
Expert 38	Regulatory Commission	Senior Assistant Director
Expert 39	Regulatory Commission	Senior Assistant Director
Expert 40	Regulatory Commission	Assistant Director