

**Multidimensional Challenges of Geo, Social & Economic
Reachability: A Step Towards Sustainable Development Goals**



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I dedicate this research work to my parents and my sisters whose cooperation and exceptional support led me to this accomplishment.

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Abstract

Internet in Pakistan is becoming an area of exponential growth. The global rise in IT infrastructure demands efficient, fast, high-speed internet while offering alternative innovative technologies. In this skyrocket era of rapid development, the most trending communication medium, the internet has been mounting than ever before. With the introduction of 3G & 4G technology, it eliminates multi-dimensional challenges and standouts for growth in evolving economy in terms of Pakistan. However, digital landscape shows there are wide areas with the dense population still unconnected with raising internet. Moreover, to address the multi-dimensional challenges there are development goals defined by Government of Pakistan in its Vision 2025 which are aligned with the United Nations' Sustainable Development goals (SDGs). All defined goals in the Vision 2025 are interconnected as it envisages Pakistan among the top ten economies of the world by 2047. Internet connectivity is a major area which is given prime importance in the vision. This is because Internet allows access to information, integrates it and uses it for accomplishing targeted goals. Our work will address United Nations sustainable development goals of poverty, good health & wellbeing, quality education, gender equality, sustainable cities and communities.

As Pakistan lies in the South Asian region comprising of mountainous, hilly, and plateau areas all of which makes internet connectivity a challenge for Pakistan. Despite of its challenging landscape, various ICT policies are being implemented for effective growth of internet and ICT. These are crucial in the development of knowledge base societies with enhanced education, economic growth, reduced poverty ratio. With the progress in the field of ICT, the achievement of sustainable development goals (SDG) will become easy to accomplish. Government of Pakistan has taken up initiatives for aiding people with improved ICT facilities. The 3G and 4G services in different cities of Pakistan have provided people an access to ICT applications and further will enable people living in rural areas of Pakistan to access services like e-learning, monitoring online banking, telemedicine, health, agriculture.

Our idea emphasizes distance-related economic, geo and social connectivity issues underlying in rural areas. As there is huge room for improvement in rural sector by optimizing reachability hindrance. On a broader view, the focused idea will be on minimizing digital connectivity challenge and its trend in the rural sector of Pakistan and devising a framework for provision of internet connectivity in rural areas. In our proposed framework, we have put forward a layered architecture to connect the unconnected people in rural areas. Our aim in this research is to give a layered approach-based framework that will provide internet to underserved rural areas of Pakistan. The framework provided can be improved by technocrats, government and local bodies according to needs of people. Additionally, the framework can be implemented by other countries which experience similar challenges and topography and resources as ours. Moreover, collaborative development plan with low cost, minimal expenditure, maximum reachability is needed. The outcome of research indicates several issues that need to be address in more holistic manner.

Key words: Sustainable Development Goals (SDG), Information Technology (IT), Internet connectivity

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List of Abbreviations

Broadband for Sustainable Development (BSD)

Cellular mobile service (GSM),

China-Pakistan Economic Corridor (CPEC)

Digital cross connect (DXX)

Digital subscriber line (DSL)

Digital Subscriber Line DSL)

Fiber to the home (FTTH)

Free-space-optical-communication (FSOC).

Gross Domestic Product (GDP)

Hybrid of coaxial and fiber cable (HFC network)

Integrated Assigned Number Authority (IANA)

Internet Cooperation for Assigned Names and Numbers (ICANN)

Internet Engineering Task Force (IETF)

Long term plan LTP

Memorandum of Understanding MoU

National Optical fiber network (NoFN)

OECD countries (Organization for Economic Cooperation and Development).

Optic Fiber Cable (OFC)

Pakistan telecommunication Authority (PTA)

Pakistan Telecommunication Company Ltd (PTCL)

Public-private partnership (PPP)
Punjab Information Technology Board (PITB)
Special communication organization (SCO),
Sustainable Development Goals (SDG)
United Nation Organization (UNO)
United Nations Development Program UNDP
Universal Service Fund (USF)
Wireless local loop (WLL),
World Health Organization WHO
World Wide Web Consortium (W3C)

Chapter 1

1. Introduction

1.1 Background

The United Nation Organization (UNO) have defined a set of 17 Sustainable Development Goals in 2015 as a United Nations Development agenda for 2030. For achieving and improving a better standard of life, technology and innovative ideas have always played a vital role in providing practical approach for making developments. Main purpose of sustainable development goals is to handle principle challenges of poverty, gender inequality, better quality education, improved infrastructure and achievement of sustainable economic growth. These involve a major role of ICT and internet for accomplishment of these sustainable development goals. However, along with these goals, Government of Pakistan also announced its Vision 2025 and all of its goals align with those of SDGs. Pakistan Vision 2025 focuses on bringing Pakistan from lower middle-income country in the group of upper middle-income countries. (J.Wu, 2018) (Tjoa & Toja, 2016)

Pakistan and United Nations Development Program UNDP in 2015 signed an Memorandum of Understanding MoU to monitor sustainable development goals. Pakistan is also collaborating with World Health Organization WHO and UNICEF for carrying out these goals in rural and urban areas. Internet connectivity is another major area which is focused in these goals. The provision of internet in rural areas of Pakistan will aid in achieving sustainable development goals through e-learning programs, e-agriculture, digital libraries, e-commerce, e-health, online jobs and much more. Our work is inspired by a study published in 2017 on connecting the unconnected New Zealanders through provision of internet in unserved areas of New Zealand.

1.1.1 Pakistan Vision 2025

Internet and ICT plays an important role in the progressive development of a country. Vision 2025 of Pakistan encompasses the information and communication technology advancement in Pakistan along with wider broadband internet access to underserved areas of Pakistan. Different incubation centers, technology parks are being built in Pakistan for technological advancement in the field of ICT. These initiatives will allow wider regional connectivity. (Government of Pakistan, 2014)

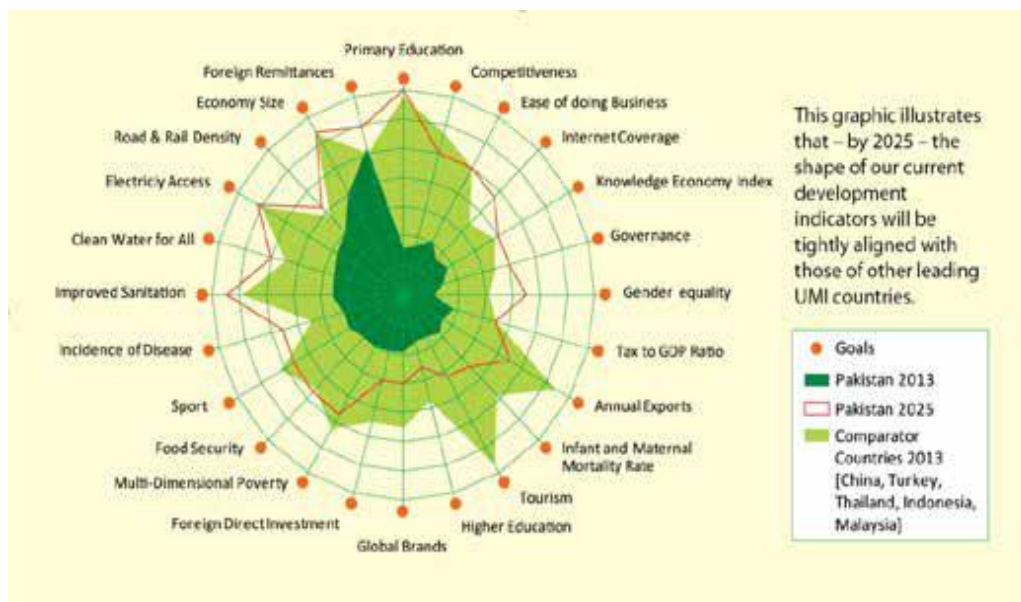


Figure 1.1 Current development indicators of Pakistan and other Upper Middle-Income countries: Vision 2025 (Government of Pakistan, 2014)

The figure above shows current development indicators of Pakistan that will be tightly aligned with those of others upper middle-income countries. Green portion highlights the comparator countries including China, Turkey, Thailand, Indonesia and Malaysia.

1.1.2. Mobile Initiatives and Broadband Penetration in Pakistan

Internet in Pakistan was introduced in 1990s. The initial internet comprised of dial-up services followed by Pakistan Telecommunication Company Ltd (PTCL) in 1995. Since then the internet users have gradually increased from 1990 and year 2000 showed 0.7% internet users of entire population of Pakistan. Initially internet was available in major cities of Pakistan targeting majority of the customers, but later Pakistan telecommunication Authority

(PTA) issued private companies license for provision of internet services to urban community. These private companies include Mobilink, Telenor, Ufone, Warid. The services provided by Pakistan Telecommunication Company Limited are widely used in all cities across Pakistan using copper cables and have expanded its infrastructure since its inception. The internet services for connectivity have initially remain dependent on Dial up internet, Ethernet cables, Digital Subscriber lines.

In 2006, another internet service provider known as NayaTel stepped into the market. NayaTel provided internet connectivity to the major cities of Pakistan using fiber to the home (FTTH) networks. The figure below depicts the variation among different internet services providers by technology they use. (Authority, 2018)

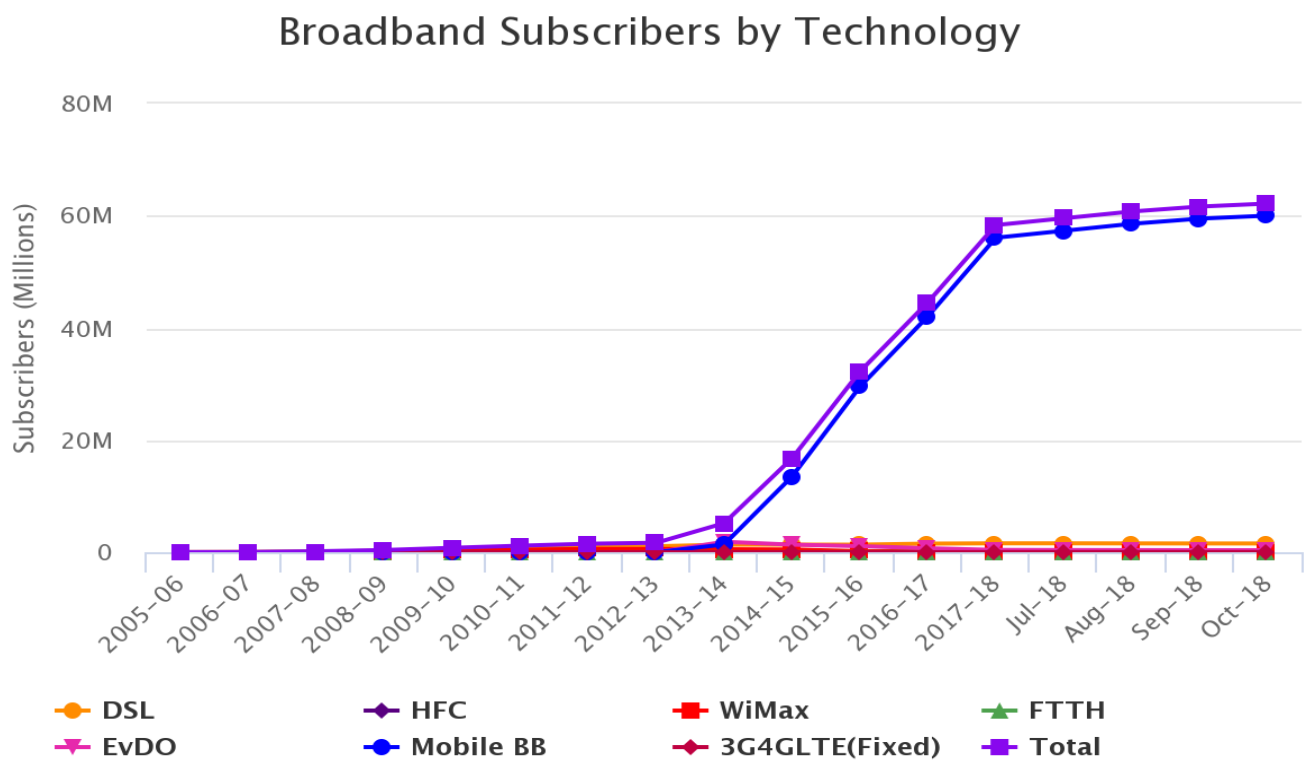


Figure 1.2 Internet subscribers by technology (Authority, 2018)

In year 2016, the broadband internet users were seen as 17.8% of total population. Although internet services expanded but its penetration rate is slow due to literacy rate, computing usage skills, equipment cost, language barrier, unavailability of services in rural areas. With

minimal per capita income seen in 2016-2017 was 1628 US dollars, it is difficult to buy computer and pay for internet services.

After the introduction of wireless services, the internet market in Pakistan has shown a significant growth. The use of low cost pre-paid and postpaid services on mobile phones have made internet accessible to wider areas of Pakistan. Mobile subscribers in year 1999 were seen as 0.27 million and increased to 449.97 million in 2017. This enormous growth is seen due to availability of 3G, 4G services.

For provision of broadband internet services, the Government of Pakistan introduced its National Broadband Policy 2012 with focus on points mentioned below. PTCL and Universal Service Fund are working together on National Broadband Policy 2012 and to achieve the mentioned milestones:

- To make broadband internet available to as much as 70 cities in Pakistan.
- Making internet affordable for all communities
- To make internet available to the educational institutions
- And ensuring government initiatives for university students, researchers and other people in academia.

1.1.3. Broadband and Telecom, Current situation in Pakistan

The Universal Service Fund was founded by government of Pakistan in 2006 with the purpose of telecommunication and internet provision to unserved areas of the country. Broadband for sustainable development and other various projects are being executed under the umbrella of universal service fund. The figure below depicts the progress of sustainable development projects. Different colors in the diagram show various phases of BSDP program. After the inclusion of 3G and 4G services internet data services are made mandatory part of this project. (Teltsche, 2014)

The United Nations member states have set a global agenda to meet the sustainable development goals 2030. The report published by McKinsey presents the population living

without internet in India, china and Indonesia combined makes up 45% of total offline population. (Sprague, et al., 2014)

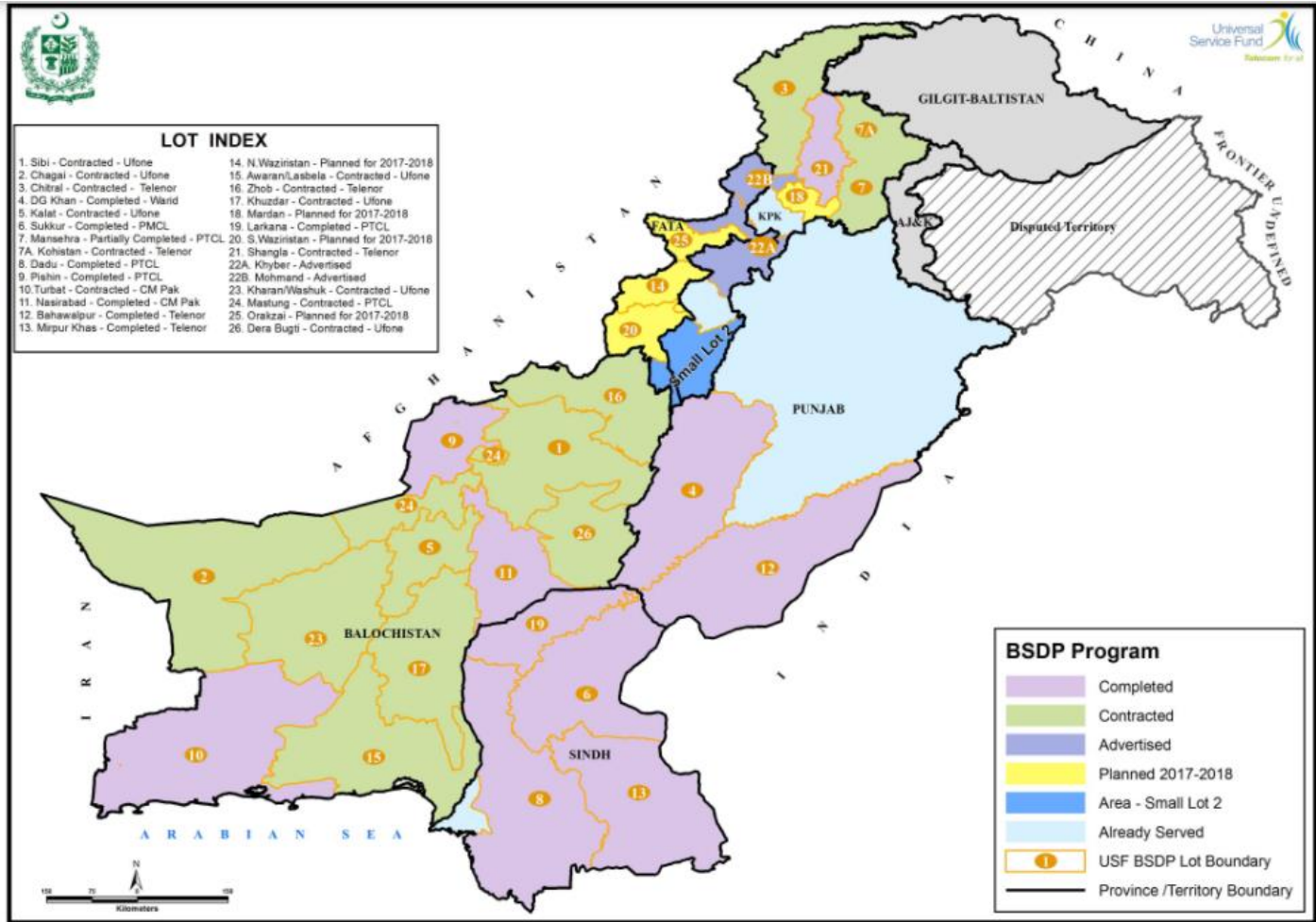


Figure 1.3 Broadband Sustainable development project process (usf.org.pk, 2018)

The figure above shows the sustainable development projects for broadband internet in different areas of Pakistan. The project is being carried out by Government initiative.

1.2. Challenges faced by rural areas of Pakistan

1.2.1. Topography of Pakistan

Pakistan is the 7th largest country in terms of population. It located in South Asian region with China, India, Iran, Afghanistan its immediate neighbors. The topography of Pakistan

comprises of hilly mountains, deserts, plateaus and plain areas. The significance of Pakistan is due to its access to warm important for trade. However different topography in different regions of country makes communication and trader difficult for people living in far areas. The census report of 2017 showed Punjab as most populated province of Pakistan whereas Baluchistan has a smaller number of populations. The other two provinces Sindh and KPK are mostly dry. Of total population of Pakistan 64% still live in rural sector without internet and other core facilities. People in rural areas live in the form of tribes.

The topography of Pakistan is one of the challenging factors in deploying the telecom and internet in rural areas.

1.2.2. Limited resources

Pakistan is among lower middle-income country whose per capita income is 1628 US dollars. Moreover, Pakistan is agrarian country and much of its GDP depends upon agriculture sector. Due to less or limited and changed rainfall pattern in winters and summers agriculture crops are being affected badly. This in turn effects the economy of the country. Exports products are limited and produce very less revenue. Along with this some cities are deprived of major health, education and hospital facilities.

1.2.3. Literacy rate and Population growth

The literacy rate in provinces of Pakistan varies. KPK and Baluchistan province have less literacy rate i.e. 50% and 43% as compared to Punjab having 61% and Sindh 63%. The low literacy rate in these provinces is due to non-availability of educational institutes. Moreover, colleges or schools does not have enough teaching staff.

With increased population there are not enough schools and colleges. The population of Pakistan is expanding at exponential rate. The population of Pakistan is expected to cross 227 million by 2025. With such growth, Pakistan needs meet challenges unemployment, health and hospitals, primary and secondary educational institutes, food and infrastructure. The figure below shows the population growth in year 1970, 2000 and expected growth in 2025. The population mainly comprises of a large proportion of young adults with 14-50 year of age.

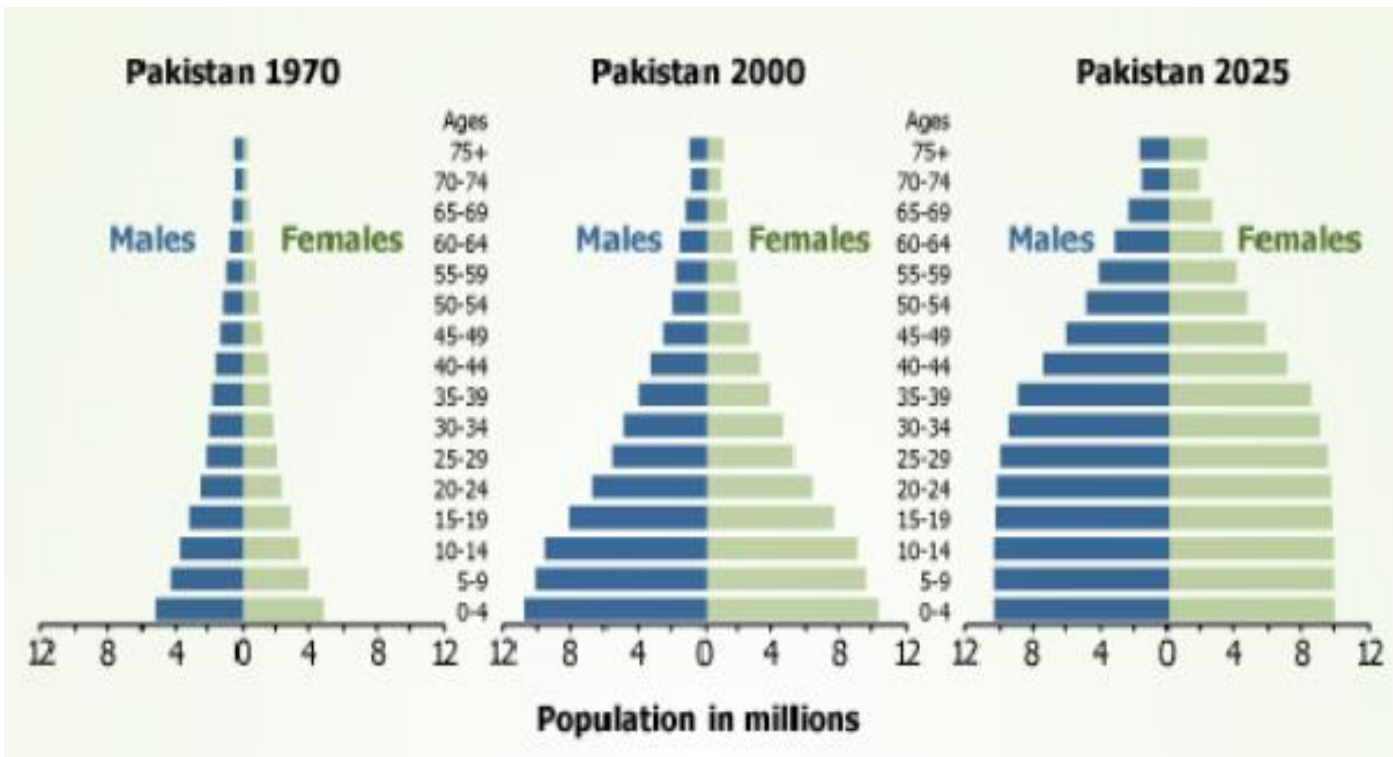


Figure 1.4 Expected Population Growth of Pakistan by 2025 (Government of Pakistan, 2014)

Table 1.1 Key Indicators of Pakistan, BTI Report 2018 (BTI, Pakistan Country Report, 2018)

| Key indicators | | | Key indicators | |
|--------------------------------|-------|-------|--------------------------------|---------|
| Population | M | 193.2 | UN education index | 0.412 |
| Population growth ¹ | % p.a | 2.0 | Gender inequality ² | 0.546 |
| Life expectancy | years | 66.3 | GDP p.c, PPP | \$ 5249 |
| Urban population | % | 39.2 | Gini index | 30.7 |
| HDI | | 0.550 | Poverty ³ | % 39.7 |
| HDI rank of 188 | | 147 | Aid per capita | \$ 20.0 |

Source (as of 2017): The world Bank, World Development Indicators 2017, UNDP, Human Development Report 2016. Footnote: 1) Average annual growth rate 2) Gender inequality index (GII) 3) Percentage of population living on less than \$3.20 a day at 2011 international prices

The table above depicts the key indicators of Pakistan, United Nations Development Index report 2017. The low literacy rate, excessive population growth, limited resources are other challenges currently face by Pakistan.

1.2.4 Accessibility of technology in rural sector

To provide internet facility to maximum people living in cities the then chief minister Punjab initiated WiFi hotspot. It available across major cities of Punjab with 200 publics locations. This WiFi has capacity to cater 800 to 1500 users at a time. Currently this initiative is being taken in Punjab province only. The wireless broadband has played significant role in connecting people living in far flung areas of Pakistan. Several ICT initiatives are being taken by government for providing rural areas with internet facility.

1.3. Motivation

The motivation behind our research is inspired from sustainable development goals. Our research focuses on devising an architecture for providing internet connectivity to rural areas of Pakistan in order to accomplish goals of good health and wellbeing, quality education, gender equality , sustainable cities and communities. The vision 2030 and SDG all share common goal of connecting people of Pakistan by providing wired and wireless internet in rural areas. With the provision of internet facility in far flung rural areas, the goals will become easy to achieve. It is not just the fields of computer science, Information Technology, Software Engineering but the internet is associated with all the other daily life applications comprising social services, health, education, infrastructure, medicine, e-learning etc. A large portion of population living in south Asian region still remains offline due to unavailability of internet. A report showed 40% of total population have access to basic internet facility whereas 15% have access to high speed internet. (Somme, Kamal, & Serrat, 2016)

Telecom sector of Pakistan is facing difficulties for providing internet due to larger portion of population living in rural areas. The internet penetration remains low in remote rural areas. However, there are wireless options available for providing internet in rural areas through WiFi, WiMAX , satellites and Balloons. (Simba, Mwinyiwiwa, Mjema, Trojer, & Mvungi, 2011) (Codr & Jain, 2008) (Ibikunle, Jakpa, & Ike, 2013)

According to ICT development index of 2017, Pakistan ranked at 148th position. Several program for sustainable development is being carried out in various provinces of Pakistan. These include optic fiber cable project, broadband for sustainable development programs, skills for youth project, early age programming and IT essentials, Telehealth services, e-agriculture, women empowerment and tele center, ICT projects, cross boarder fiber optic cable for digital connectivity and internet.org project. These initiatives aim at facilitating people living in urban and rural sector.

Investment in IT sector accounts for economic development and GDP growth of the country. Countries like USA, Canada, UK, Australia, France, Sweden, and Denmark have shown an optimal growth towards ICT sector. These countries have a paved way in terms of Internet and ICT progress for developing countries like Pakistan. For ICT and Internet connectivity several initiatives such as rural telecom program, fiber optic project and special project are carried out under USF Telecom and e-service programmed. It aims to improve rural tele density through Internet access to far areas using following a public-private partnership approach, shared services between government and private organizations. (Khan & kamal, 2013) (society, 2015)

The approach used in rural areas of other countries for internet provision is by means of using satellite, wireless 3G, 4G internet. Wireless internet actually costs less than the wired internet connection. Our framework provides a solution in order to achieve sustainable development goals through provision of internet in rural sector. It provides a combination of wired and wireless rural access internet technologies. Our framework aims to maximize the services provided by internet to be reachable to maximum number of people of rural sector.

1.4. Research Questions

Based on our motivation, the following research questions will be addressed through our research study. These comprise of :

- i. Which factors are affecting the ICT and Internet progression in Pakistan?
- ii. How Sustainable Development Goals can be achieved through provision of internet?
- iii. What kind of framework can address this issue and will be suitable in case of Pakistan?

1.5. Research Objectives

With the growth of internet in today's world, we see that more researches and advancements are being made in the field of broadband internet. Much of the work is being done on keeping the internet robust and available for majority of population. Different kinds of internet service provider technologies are being used in urban areas some rural areas of different countries. With the advent of wireless 3G, 4G and WiFi, internet services are easily accessible to majority of population living in different cities of Pakistan.

Apart from making the internet more robust and available in urban areas, an area of focus nowadays is more towards provision of broadband internet in rural sector of Pakistan. To connect the unconnected Pakistan through provision of internet in unserved areas. The provision of internet services will aid in achieving sustainable development goals of well being , health , education etc.

Different types of services are being provided in various countries for internet connectivity in rural and urban areas. Some uses wired or wireless 3G, 4G technology while some are using DSL and broadband technologies providing internet accessibility to far areas. Based on our empirical research, we have given framework that allows various internet connection to rural areas of Pakistan. In our given framework i.e a layered architecture, all layers are interconnected with each other for provision of cheap and robust internet.

Following are the research objectives we have set of our research:

✓ **Sustainable development goals**

To achieves sustainable development goals by providing means of internet in rural and far flung areas of Pakistan.

✓ **Internet provision to the rural areas of Pakistan**

To connect the unconnected people of Pakistan by providing them wired and wireless internet. Our framework include multi-layer structure comprising of research and development, multi-stake holder collaboration , outsourcing private companies followed by rural internet access technologies.

✓ **Affordable and Low-cost internet**

Also, we shall provide our framework in the form that it takes less cost for acquiring internet connection.

Following are the Sustainable Development Goals of our research:

✓ **Sustainable cities and communities**

By providing wired and wireless internet connection, the framework shall approach to manage cities and rural communities more effectively.

✓ **Quality education**

With the provision of internet to far flung areas, a major chunk of population living with no means of education will be able to take online classes, tutorials through distant learning projects.

✓ **No poverty**

Internet is becoming rich in providing online jobs, freelancing, distant work from home and other resources to earn money. With provision if ICT and internet services people can earn a job at home and can make handsome earning.

✓ **Good health and well being**

This goal will be achieved by providing telehealth and tele medicine facilities over the internet in rural areas of Pakistan

✓ **Gender equality**

1.6. Structure of Thesis

The rest of the thesis is organized as follows :

Chapter II covers the literature review about the topic. It gives detailed study about IT initiatives taken in Pakistan and similar work done in different countries. It also outlines province wise analysis of Pakistan and projects being carried out here. This chapter also covers the in-depth analysis on evolving techniques and practices for rural and urban connectivity in other countries.

Chapter III states methodology and proposed framework for our research problem, current state of internet in Pakistan, challenges and constraint in the developing the internet ecosystem in Pakistan. Lastly, the chapters present a detailed layered framework for our research problem as a solution which can be further improved.

Finally, chapter IV and V summarizes the research by providing a conclusion, limitations that hinder the provision of internet in Pakistan and future work .

Chapter 2

2. Literature Review

The role of ICT in the past few decades has been improved. It is also crucial in the development of knowledge base societies with enhanced education, economic growth, reduced poverty ratio. The inception of 3G/4G and innovative ICT services in different areas of Pakistan are the source of providing maximum advantage to people. This section will discuss province wise analysis of network connectivity initiatives being taken in different provinces of Pakistan. Moreover, similar comparatives studies of other countries are also being discussed below.

2.1. IT Initiatives in Pakistan: A Province wise Analysis

The ICT policies can improve Pakistan's knowledge base economy if they are implemented effectively. It is also crucial in the development of knowledge base societies with enhanced education, economic growth, reduced poverty ratio. (SHAIKH & KHOJA , 2011) With the progress in the field of ICT, the achievement of sustainable development goals (SDG) will become easy to accomplish. Government of Pakistan has taken up initiatives for aiding people with improved ICT facilities. The 3G and 4G services in different cities of Pakistan have provided people an access to ICT applications. These services benefit people by providing them with wireless internet connection. The 3G and 4G internet technology will enable people living in rural areas of Pakistan to access services like e-learning, monitoring online banking, telemedicine , health , agriculture and much more (Imtiaz, Kha, & Shakir, 2014)

Our literature review includes the study about initiatives taken in different provinces of Pakistan for growth of ICT. It also include case studies from few countries that are in process of providing internet and ICT services for people living in rural areas .In order to understand different factors, we have carried out study on different provinces which will be explained in upcoming headings.

2.1.1. KPK AND FATA

Khyber Pakhtunkhwa (KPK) is among the provinces of Pakistan with population of about 30,523,371 that is contributing to 14.6% of total population (wikipedia, n.d.) .A wide ratio of people still live in isolation due to non-provision of internet facility in far areas .Once internet and ICT services are made available , people will be able to access various online services of online learning , e-banking , health , education. Below given are various ICT projects that aims of bridging gap between people and technology by proving internet facilities.

Optic Fiber Cable Project

The Optic Fiber Cable (OFC) project is initiated for the purpose of providing internet and ICT service in Kpk. The project serves the purpose of enabling people in kpk with internet availability . This project will serve 3.2 billion people of Kpk. (Desk, 2017)

Broadband for Sustainable Development Program

Broadband for Sustainable Development (BSD) is a program whose purpose is to improve and expand internet connections in unserved areas.

This project is given to Pak Telecom Mobile Limited which will cover different unserved lands of 35,100 sq km and 16,500 sq kms . Through this program people will be able to access enhanced e-services through new and robust Internet network. The main idea behind this program is to bridge gap by providing better ICT services in far flung areas.

Of the total population of Pakistan, 64% comes under the umbrella of rural sector. Hence a large portion of population have limited or no access to internet facility. The infrastructure challenge of social, cultural barriers hinder the growth of ICT . Urban sector in Pakistan is getting better internet and ICT as compared to its rural sector. The ICT and internet facility in remote areas is believe to minimize the barriers between rural and urban sector. A study reveled an internet to be a principal factor in development of rural sector. (Kurniawan, Zakia , Wartika, & Austin, 2015)

Skills for Youth Project

For achieving SDG and better education IT skill project is initiated in partnership with U.S. The project will mainly focus on students of FATA and Kpk .

This program will further provide training and Cisco-certifications in KPK province. More than 3000 students will benefit including men and women. The strategic objective lays great stress on learning employability skills through training for the economic development of the country. The efforts for achieving the SDG and 2025 vision are underway for the development of urban and rural areas. Certain problems are encountered which hinders economic development. Of which poverty and low literacy have a high ratio. The current provision of broadband connections and ICT reforms are likely to assist people acquiring improved education. (pk.usembassy.gov, 2016) (Khan M. , 2014)

Early Age Programming and IT Essentials

The advancement in technology and digital applications have made markets more competitive. For students to get familiar with ICT knowledge, this program will help students to learn coding techniques. Programming can provide students with techniques for solving a problem using critical thinking. Students of now can become coders of tomorrow. (Saeed, 2017)

Telehealth Service

The ICT services are introduced in order to bridge gap between urban and rural sector. The rural sector is devoid of basic health facilities. This will not only boost development in health sector of rural areas but will also benefit people living there with services like e-ilaj and remote tele health facilities. (Farooq, 2017)

E-Agriculture

Pakistan being an agrarian country, most of its economy depends upon agriculture. Almost 19.8% of gross domestic product (GDP) is contributed by the agriculture sector. Percentage of the rural population dependent on agriculture business is 42.5%. E-agriculture using ICT service can aid farmers in making improved and timely decisions. New ICT technologies and

applications are introduced for the farming community including weather forecast, harvesting season intimation etc. These aim at benefiting farmers with improved rural livelihood and agriculture production.

Aldosari, F. et al. (Aldosri, Al Shunaifi, Ullah, Muddassir, & Noor, 2017) studied the need for ICT in agriculture sector. It was observed that for better production, farmers need to have timely information. This can provide farmers with beforehand measures for pest control, drought, sudden flood conditions, varying weather, and rainfall. Electronic media, TV, the Internet, mobile phones share useful information and effects positively towards agricultural growth.

2.1.2. BALOCHISTAN

The total population of Balochistan is 12,344,408 contributing to 5.94% of entire population of Pakistan. It is largest in terms of land area and also dominated by natural resources. People living in distant regions in province have limited access to Internet facility. As compared to other provinces of Pakistan Balochistan accounts for the lesser number of ICT initiatives due to poor Internet penetration, low literacy rate, lack of digital skills and resources. For sustainable development, various broadband projects are introduced in Balochistan. These aim to provide ICT services for improved growth in ICT and telecommunication (Arfeen & Nielsen, 2017)

Broadband for Sustainable Development

This is an initiative by Universal Service Fund (USF) project of deploying optic fiber cable in Balochistan province. The project was given to Pak Telecom Mobile Limited (Ufone) to provide 3G services to unserved areas of 40,000 sq km. The project is expected to facilitate 12.8% of the area and 6.5% of the unserved population of Balochistan.

Women Empowerment and Tele-centers

In Balochistan few other initiatives have been taken . one of them is Establishment of 50 computer labs for women empowerment centers is also stated to be part of a project for women with lower income. For high-speed Internet connectivity, broadband connections will be laid down covering a different part of Balochistan and other areas in its vicinity.

Deployment of 500 tele-centers is also planned by universal service fund for telecommunication in far areas.

2.1.3 SINDH

Sindh comprising of 47,886,051 people, that makes it the second largest province by population contributing to 23.04% of the entire population. The province has two largest seaports and one of the biggest international airports located in Karachi.

Mega-Projects

In order to provide advanced IT tools and technology, two mega projects are under execution, Arfa Karim Information Technology (IT) City and Geographical Information System (GIS). (2012)

ICT Project

For better-quality education, Sindh government has provided schools with LED screens, tablet computers, solar panels as a part of the ICT project. An e-learning application using android based platform has been developed for math and science subjects. (Nawaz, 2016)

ICT is helpful in the student as well as professional life as it plays an important role in the integrated environment of learning. But some far-flung areas and rural sectors are still deprived of basic ICT facilities. (Jafri, Soomoro, & Khan, 2011)

2.1.4. PUNJAB

Punjab is the most populated province of Pakistan. The province is rich in ancient civilization, cultural heritage, fertile agricultural land, Indus River and its four major tributaries in Pakistan, the Jhelum, Chenab, Ravi, and Sutlej rivers the "five waters" of Punjab. It's also has varied temperate zones that makes it best for agriculture. The Punjab province is also hub of major industries, educational institutes, health care system, ICT and IT technology parks.

Cross Boarder Fiber Optic Cable for Digital Connectivity

The China-Pakistan Economic Corridor (CPEC) is a framework providing regional connectivity and geographical linkages between the two countries. The framework also focuses on providing means for improved digital connectivity under Long Term Plan 2017-

2030 (LTP) for Pakistan. The plan aims at upgrading Internet connectivity by fiber optic cable resulting in the direct linkage of Pakistan with China. A total projected cost of \$44 million is to be expected from Khunjerab pass to Rawalpindi.

According to long term plan LTP, these Internet connections will be of huge advantage to people living in Balochistan and Gilgit Baltistan. As these provinces have limited or no access to Internet availability, with 135km long optic fiber cable starting from China Tashkurgan Tajik to connect it with Pakistan. Further 125km cable will pass from Khunjerab from all the way to Gilgit Baltistan which covers 650km distance and links to Islamabad (Haque & Siddiqu, 2019)

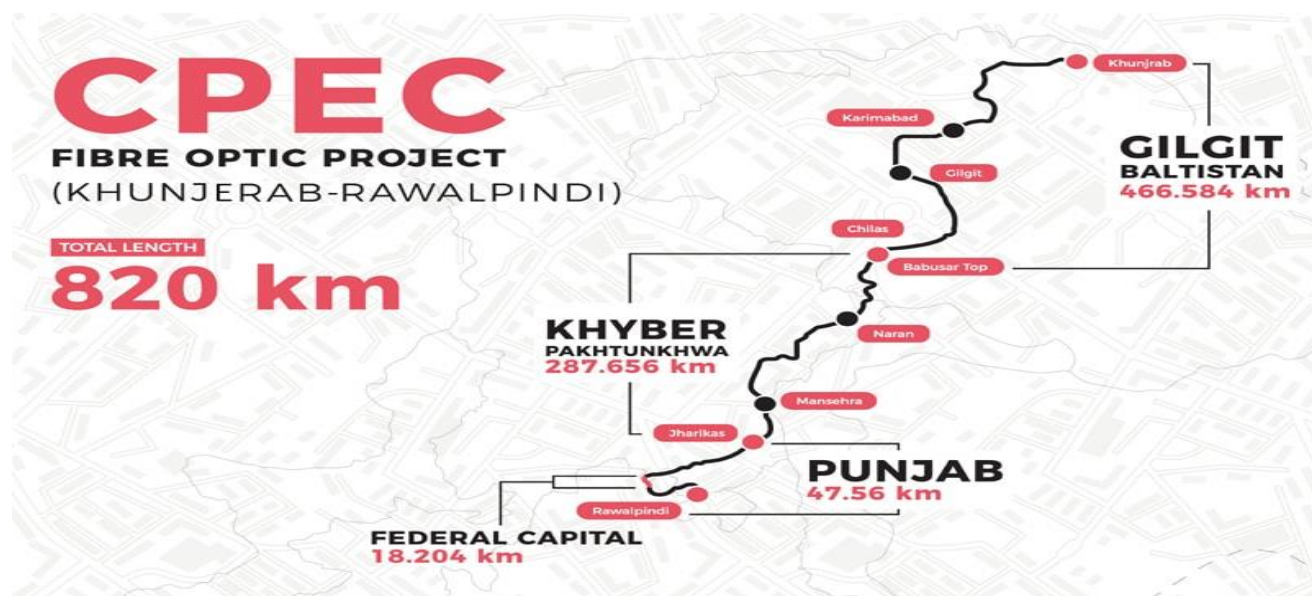


Figure 2.1 Pakistan - China Fiber Optic Project (Haque & Siddiqu, 2019)

Punjab's 5 pillar IT policy

The 1st ever IT policy for province of Punjab has finally been passed in year 2018 (Rehman, 2018). The policy consists of five pillars:

- i. **Supporting the Information technology Industry.** It will include building and development of technology parks, promotion of e-commerce, user friendly policies ,introducing the information technology in non-IT sector.

- ii. **Bridging the digital divide gap.** This consist of providing free wi-fi and hot-spots for internet use , e-libraries, strengthening cyber-security, e-Rozgaar program. Some other initiatives taken by Punjab Information Technology Board (PITB) are Data Protection Act, Right to Information Act, Right of Policy will aim at facilitating the citizens of Punjab, Pakistan
- iii. **Initiating e-governance system.** This aims at monitoring government offices through use of ICT in the field of health care, police, traffic, judiciary, education, land records and agriculture.
- iv. **Citizen centering services.** This fourth pillar of IT policy will focus on services provided to citizens of the country Pakistan. The services provided include e-Khidmat centers, e-Payment service methods, Citizen Contact Centers, and Citizen Feedback Monitoring Program.
- v. **Entrepreneurship.** The term focuses on starting up a successful business and promoting it. Two technology incubators for business startup named as Plan9 and PlanX are already launched in Punjab. These serve as tech hub for connecting the entrepreneurs and freelancers. Additionally, an e-Rozgaar program aim to support freelancers and entrepreneurs for running up their successful business.

Digital Punjab, Enhancing Public Services Through Technology

The Punjab information technology board initiated for an IT-driven reforms in the province of Punjab (htt) .These comprise of reforms in health sector such as disease surveillance system , dengue tracking system , drug testing laboratory automation and few more. For Law and order electronic FIR system is introduced. Education sector include online admission system , e-learning initiatives. Services for citizens consists of e-Khidmat Markaz, Punjab Free WiFi Hotspots, Citizen Feedback Monitoring Program , Management System for driving license ,Management System regarding Domicile and Complaints Management for Overseas Pakistanis. Other initiatives include e-agriculture program, technology parks and tech hubs.

2.1.5. AZAD KASHMIR AND GILGIT BALTISTAN

Azad Kashmir and Gilgit Baltistan are said to be most hilly, mountainous regions of Pakistan. Both are of importance for promoting tourism. Despite of their significance these regions face challenge of internet , telecommunication and ICT. Special communication organization (SCO), a public sector organization working under the umbrella of Ministry of Information and Technology, government of Pakistan is responsible for providing telecom and ICT services in these regions. For provision of Internet and communication services in rural and urban areas of Azad Kashmir and Gilgit Baltistan. SCO has laid over 4800 kilometers Optical Fiber Cable network across the entire region. The technology used by SCO in order to provide these regions with ICT and internet services include line telephony (PSTN), wireless local loop (WLL), cellular mobile service (GSM), broadband internet (DSL), digital cross connect (DXX). In 2007, SCO initiated its internet services under name of SNET. SNET is responsible for providing broadband internet access over DSL, WiFi and fiber optic cable. (Organization, 2018)

Internet.org Project

The digital and information revolution has changed the way of communication. For same purpose Facebook has initiated one of its Internet free access project titled as Internet.org (kemp, 2017)

It is a partnership between Facebook and telecommunication companies with the aims to bring Internet access to less developed countries. These tech giants aimed at developing joint projects, knowledge sharing, and mobilizing governments. This application is renamed as Free Basics in September 2015. When users choose Free Basics, the carrier plugs them directly into Facebook servers only, but it is not the Internet. It addresses the afford-ability and awareness challenges by giving people a way to experience the Internet for the first time with zero data charges.

Internet.org was launched on August 20, 2013. It is available in 38 countries, all of them are located in Africa, Asia, Middle East, and Latin America. Till November 2016, 40 million people are using internet.org. The Internet.org contributed to monthly users growth, which

accelerated from 3.63 percent to 4.67 percent since last quarter to hit 1.79 billion. It is now live in 30 countries with 34 telecom operators.

Mark Zuckerberg launched Internet.org in Pakistan on 28 May 2015. In 2015 study showed only 15% of Pakistan's had access to the internet. The project is supported by Telenor through 2G and 3G services. It can be used by any Telenor SIM holder in Pakistan from any city. This offer is available for both prepaid and postpaid users.

With this initiative 17 websites can be accessed freely using Internet.org and out of which 12 are international while 5 are local websites. The websites are Facebook, Facebook Messenger, IlmKiDuniya, Mustakbil, OLX, Telenor News, Urdu Point Cooking, Malaria No More, BBC Urdu, AccuWeather, Baby Center & MAMA, BBC News English, Microsoft Bing, ESPN Cricinfo, Facts for Life, Girl Effect and Wikipedia.

Internet in Pakistan is becoming an area of exponential growth. The global rise in IT infrastructure demands for efficient, fast, high-speed internet while offering alternative innovative technologies. In this sky rocket era of rapid development, the most trending communication medium internet has been mounting than before. With the introduction of 3G & 4G technology it eliminates multi-dimensional challenges and standouts for growth in evolving economy in terms of Pakistan. However, digital landscape shows there are wide areas with dense population still unconnected with raising internet. Our idea is to perform survey for rural sector confronting distance-related economic, geo and social challenges underlying and analyzing measure of attainable goal in next 10 to 12 years. Determining Internet investment initiatives taken by our government and private agencies for its expansion and growth. As there is huge room for improvement in rural sector to minimize this hindrance. On broader view, the focused idea will be performing simulation on rural area infrastructure and deploy connectivity model in rural sector by identifying best practices.

For provision of internet connection to urban and rural areas wide range of initiatives are being taken in various countries. Literature review will provide brief summary of the initiatives currently being taken place in various countries. These include New Zealand, India,

Tanzania and DRC (Democratic Republic of Congo), Mauritius, Singapore and some other google projects.

The government of New Zealand defined its goal of broadband availability to 99% of kiwis by 2025. It initiated to projects named as Ultra-fast broadband (UFB) divided into two phases UFB-I and UFB-II. The other project for provision of internet is rural broadband internet (RBI) divided into two phases as RBI-I, RBI-II. The MahiTahi, top down and bottom up partnership approach is projected for achieving defined goal. The project for providing internet to 99% of kiwis of new Zealand being divided into different phases aim at providing fast Internet penetration to rural and unserved areas of New Zealand by end of 2019. (Villapol, et al., 2017)

Similarly, the government of India has initiated Baharat Net project formerly known as National Optical fiber network (NoFN) India, that will make internet accessible to people living in rural areas by 2020. The government of India has divided the project into different phases i.e BaharatNet project phase-I , BaharatNet project phase II. The project aims at making broadband and internet accessible to the people living in rural sector, far flung villages, schools, small scale business, cafes and for households. (Nagy, 1994) (Manzar, Srivastava, & Kumar, 2015)

For providing internet facility to majority of the people living in India, Google is also using light beam technology to connect people living in rural India, using free-space-optical-communication(FSOC).The technology will be able to deliver high speed connectivity to population living over longer distance.

The majority of population living in Global south have very limited or scarce access to Internet. The two of African countries situated in South are Tanzania and DRC (Democratic Republic of Congo), falls under category of having limited internet availability. A project funded by research council of Norway , has set its vision for 2030 to provide ICT and communication infrastructure for digital access to these countries.

The Non-discriminating access for Digital Inclusion (DigI) is a 3 year project aiming at connecting the unconnected people for digital health, education, extensive mobile network. (Johansen, Johansen, & Noll, 2018)

Mauritius also has taken initiative for development of ICT sector through National Broadband Policy 2012-2020. The Mauritius government has actively formulated programs and policies for social and economic development. The govt seek a holistic approach towards its ICT policy. Telecommunication is not only limited to national market players, but international companies also are part of policy. (Teo & Lim, 1998)

The table below shows the 3I index data for 5 countries comprising China, Congo (DRC) , India , Pakistan , Tanzania. The table contains data that depicts the percentage of population by respective countries that can access 2G network coverage, 3G network coverage and 4G network coverage. The table also contain field that depicts government and private initiatives for making Wi-Fi available on the scale of zero to two. It also holds the rating on the scale of zero to two for national broadband strategy, availability of e-government services in the local language and support for digital literacy in these 5 countries.

Table 2.1 3I Index Data

| <i>Countries</i> | <i>China</i> | <i>Congo (DRC)</i> | <i>India</i> | <i>Pakistan</i> | <i>Tanzania</i> |
|---|--------------|--------------------|--------------|-----------------|-----------------|
| <i>Network coverage (min. 2G) / % of population</i> | 99.5 | 50 | 93.46 | 87 | 95 |
| <i>Network coverage (min. 3G) / % of population</i> | 97 | 20 | 79.67 | 67 | 85 |
| <i>Network coverage (min. 4G) / % of population</i> | 97 | 0 | 73.5 | 27 | 13 |
| <i>Government initiatives to make Wi-Fi available / Qualitative rating 0-2, 2=best</i> | 2 | 0 | 2 | 1 | 0 |
| <i>Private sector initiatives to make Wi-Fi available / Qualitative rating 0-2, 2=best</i> | 0 | 0 | 2 | 0 | 2 |
| <i>National broadband strategy / Qualitative rating 0-2, 2=best</i> | 2 | 0 | 2 | 2 | 1 |
| <i>Availability of e-Government services in the local language / Qualitative rating 0-2, 2=best</i> | 2 | 1 | 2 | 1 | 1 |
| <i>Support for digital literacy / Qualitative rating 0-3, 3=best</i> | 3 | 1 | 2 | 0 | 3 |

TABLE II
3I-INDEX-DATA

The strategic option for building a next generation NBN intrastate in Singapore comprised of government, investment incentive approach and giving relief to existing operators. Hence correlation of both public and private sector

To deliver internet services in developing countries, Google have started its efforts with Project Loon -using massive balloons floating above earth surface. It will be able to provide internet connectivity to rural and unreachable areas. Loon aims at working in collaboration with mobile network operators for expansion of LTE service (high speed wireless communication) (Dahir, 2018)

Our framework deals with providing a layered architecture for provision of internet connectivity in rural areas. This is done by using rural internet access technologies for flung areas to connect the unconnected population. as the transfer media. In this section, the work related to wired and wireless internet and its connectivity are highlighted briefly, which greatly relate to our research domain.

Chapter 3

3. Methodology And Proposed Framework

3.1. State of the Art Analysis

In recent years, Pakistan has mainly focused on ICT services and Internet connectivity for integrating into the global economy. Telecom industry and IT sector in the past few years are largely seen as sources of sustainable social and economic development. Through public-private partnership (PPP) various projects are under the way in shaping the country's vision. Further, for successful achievement of sustainable development goals and vision 2025, a series of projects have been initiated along with Internet proliferation and ICT progression. As of June 2017, broadband penetration observed 22.6% in 2016 raised to 24.5% in January 2018. This growth in the digital evolution of Pakistan landmarks the countrywide connectivity. Its covers mostly urban and sub-urban areas, however the rural sector is still deprived internet facility.

For past few years, ICT is playing a major role towards the inclined growth of country's economy. Acting as a progressive tool for both socio-economic and human development. More focused, citizen centered ICT strategies are needed for successful growth in internet infrastructure. A comprehensive overview of Pakistan IT and telecom industry shows growth of 7% to 24% in past years; various projects for implementation of ICT with help of other partner countries such as Korea, China, Canada, USAID and large enterprise like Microsoft are significantly assisting Pakistan with IT project .

The other projects like Benazir Income support Programme (BISP), e-health, tele medicine, e-agriculture, virtual university, Digital Libraries, Certification programs, technology infrastructure, Safe city project, Optical fiber project, Broadband penetration are initiatives

taken by Government of Pakistan contributing towards achievement of sustainable development goal

Universal Service Fund, Pakistan Telecommunication Authority , Ministry of Information and Technology and other private organizations need to plan comprehensive strategy to deploy broadband and wireless Internet in un-served areas,ensuring low cost and availability of internet service.Federal-provincial,inter and intra-provincial plans should also focus on internet connectivity infrastructure that provide easy access to unreachable and geographic challenged areas.

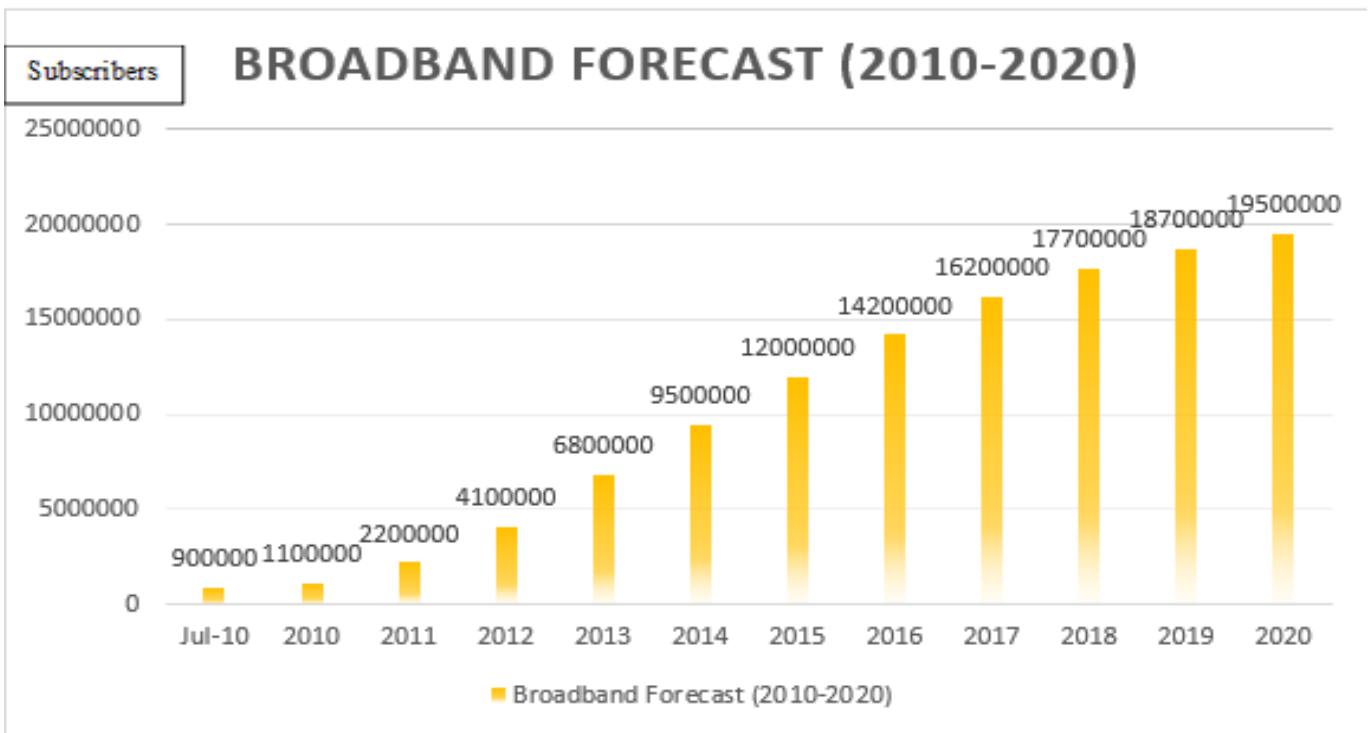


Figure 3.1 Broadband forecast, Pakistan (Pakistan, 2010)

Similar problems for provision of internet are being experienced in other countries. Yet, despite of constraints, these countries have taken measures and developed frameworks which address the need of people for acquiring internet connectivity. These majorly consist of framework which involves government initiatives, public private partnership and outsourcing connectivity projects. In the study of New Zealand to provide internet facility to

rural and urban areas ,the developed framework is termed as “the top-down bottem-up Mahitahi approach”.

In an other study of India , the government of India has taken initiative to provide its citizen with internet facility through BaharatNet project. On the other hand Google is also using light beam technology to connect rural India using free space optical communication.

Taking study of Mauritis, the government has development National Broadband Policy for providing internet across the country.

3.2. Current State:

The Internet penetration and speed in Pakistan is better developed than before. The average Internet connection speed in Pakistan is observed to be 2326.0 Kbps until now. The figure below closely illustrates on the scale of 100, the broadband speed percentage in Pakistan. A total of 6.2% of entire population of Pakistan have access to only 4Mbps internet speed. Only 0.4% of people have access to 10Mbps Internet speed, 0.1% have 15Mbps broadband speed and lastly only 0.0% have 25Mbps Internet speed. The internet speed percentage varies across Pakistan because of less, poor and inefficient connectivity.

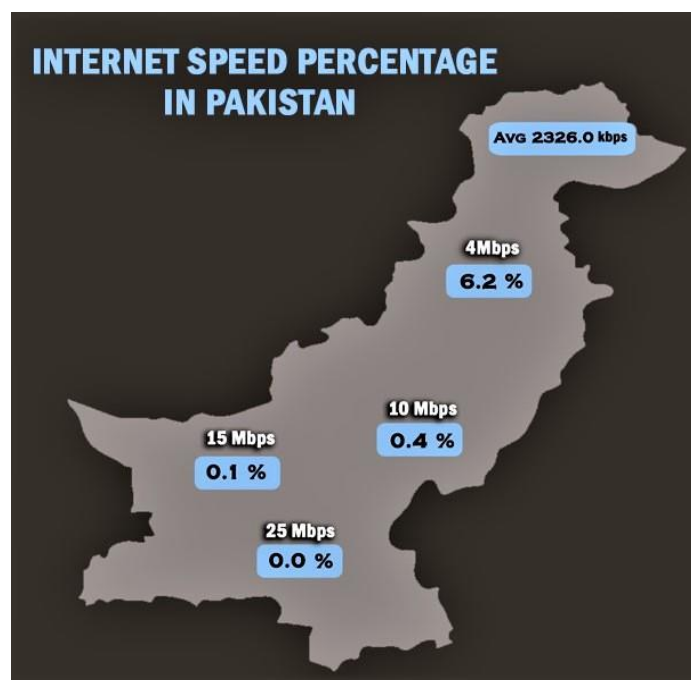


Figure 3.2 Broadband speed percentage across Pakistan

With broadband, digital divide initiatives and optical fiber projects, the pace of Internet penetration to unreachable areas have been some one accelerated. Internet and ICT seem to have huge economic and technological impact; since through its proliferation and optical fiber projects, broadband connections are made available to rural and far-flung areas. People living in urban and sub-urban areas have found it helpful with their online transactions, shopping bills, shipping orders, flight reservations, distance learning, live streaming, e-book availability, and e-payments.

It is also largely seen to be accessed during political campaigns, emergency government situations, political crisis, and media campaigns. The medium is used to access blogs, news reports, online web streaming, videos, photos and in the state of an emergency situation where television broadcast becomes immobile.

People from diverse cultures and backgrounds share ideas on platforms like Facebook and Twitter. A large number of people especially women are seen working from home in some rural areas due to ease of the Internet and its availability. With broadband penetration to wider areas, more people will have access to job information, entertainment, live updates, and online education. Those living with diverse culture or religion share traditional events with others through means of the Internet.

To connect the unreachable areas, different technologies are being used to deliver internet services across Pakistan. The primary delivery technologies that are being used are; copper telephone line (Digital Subscriber Line DSL) , hybrid of coaxial and fiber cable (HFC network) , wireless (Broadband wireless access network) , Satellite.

3.3. Challenges/ Constraints in Developing Internet system

Due to lack of research and development (R&D) , inefficient framework for ICT and internet deployment , inadequate collaboration between public-private parties , less effective policy development plans, scarce resources these all together hamper the regional connectivity. However, technical and physical collaboration between makers of internet ecosystem can pave way for such challenges. These comprise of Internet Engineering Task Force (IETF) , the World Wide Web Consortium (W3C) , global and local organizations

such as Internet Cooperation for Assigned Names and Numbers (ICANN) , Integrated Assigned Number Authority (IANA) . The local network operators serving in Pakistan for the delivery of internet are (PtcI,Nayatel,Wateen,COMSATS Internet services) and many other service providers.

As,

- i. homes are sparse in rural areas.
- ii. distance creates difficulty in propagation of signals
- iii. challenged geographic location,hilly areas

for all these cost effective strategy for internet access to rural areas is another important aspect.A comprehensive strategy from technocrats can provide sound and thorough practical solutions for achieving targets.A balanced development plan with low expenditure and higher outcome is needed. As seven goals of vision 2025 are interrelated with each other. For each of them government should focus on implementing fundamental requirements first. Because till 2025 our population would be grown exponentially so measures should be taken into account for that as well.

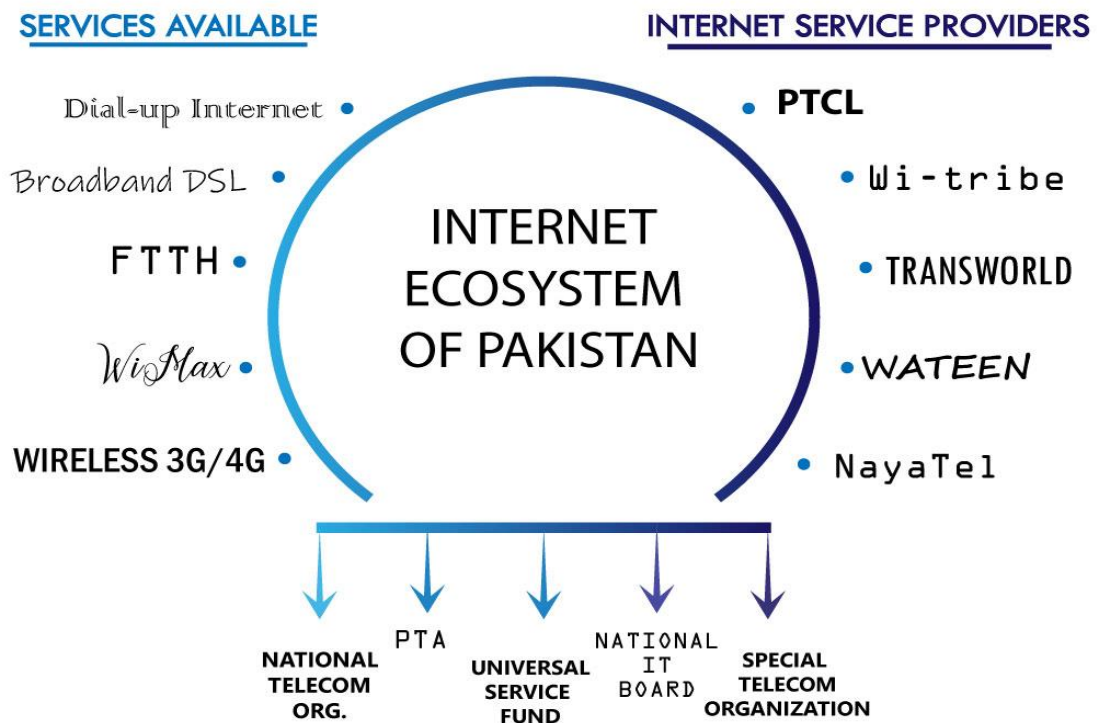


Figure 3.3 Elements making internet ecosystem of Pakistan

The elements that make up internet ecosystem of Pakistan comprises of several government and private bodies , internet service providers and the internet services they provide. The government bodies responsible for internet provision include Pakistan Telecommunication Authority which is state owned body. It provides services of establishing , operating and maintaining telecommunication in Pakistan. Likewise National telecommunication , Universal service fund , National IT Broadband and Special communication organization are other government operators that are responsible for telecom services in Pakistan .

The other element that builds up the internet ecosystem includes service providers namely PTCL, Wi-tribe, Wateen, NayaTel. These are responsible for providing dial-up internet , broadband DSL , FTTH, Wi-Max and 3G, 4G services in urban and few rural areas in Pakistan.

3.4. Layered Architecture Approach

We have chosen layered architecture for our problem because it involves step-by-step implementation of each phase completely before the other. This layered architecture will enhance the multiple entities participation and coordination in devising more effective framework with minimum cost and maximum output. Moreover, this architecture will enable diverse players to integrate on different layers of architecture in order to make the framework work for delivery of internet in rural and far flung areas. This layered architecture approach be cohesive.

There are various architectures being implemented in different countries for the provision of internet. However, in our case Pakistan is confronted by challenges of topography, security, infrastructure, economy, underdeveloped areas. These all hinder the progress of ICT and internet in the region. To enhance the connectivity of internet in rural and unserved areas, the layered approach will allow technology experts, and policy makers to understand these challenges on each layer. This breaks down the architecture into sub-layers each depicting the challenges it confronts and each layer will deal with different dynamics and concerns. The separation among layers enables different market players to provide their own services with equipment available for provision of internet.

The internet ecosystem of Pakistan comprises of government and multiple owned private companies. For internet provision to urban and sub-urban areas of Pakistan technology like wireless 3G,4G, digital subscriber line (DSL), optical fiber networks, WI-Max are currently used. However rural sector has very limited or no access to internet. For achieving sustainable development goals, the internet acts as powerful engine. Its unavailability in rural sector hinders the development of social and economic growth.

We use figure 11 to illustrate a 5 layered framework architecture for provision of internet in rural area. Its layered components involve government R&D frameworks, multi-stakeholders, outsourcing to private organizations. Initially the first layer is organized in way that it will allow collaboration between government organizations (acting as a catalyst) and research and development (R&D) framework. The government agencies will provide data set for rural areas with low or no connectivity. As landscape of each province of Pakistan is different from the other, so feasibility study research and development will provide best suitable strategy. Once the feasibility model is developed it will then be incorporated in second layer. The second layer is characterized as building of internet infrastructure through partnership of multi-stakeholders who provide internet services along with outsourcing of projected model. This will aid in saving cost, promote efficiency, offer flexibility, access to skilled resources and quality services. This will allow rural infrastructure development. Next layer provides options of rural access technologies which may be deployed in order to provide internet connectivity and ICT services in rural and unserved areas. The rural connectivity for various provinces of Pakistan differs accordingly. A long range WiFi antenna may serve population of few hundred people living in a village whereas DSL and fixed wireless may be implemented in areas that require robust and efficient internet. After deployment of suitable internet architecture, people can access and facilitate them with various online applications of e-learning, telehealth, e-agriculture, online banking, free lancing, distant learning and some more.

In our layered approach all the layers vertically affect each other and hence are interdependent. The architecture shows provision of internet to rural areas can be made possible using Satellite internet, wireless infrastructure, hybrid association of wired and satellite, tethering hot-spot, long range WiFi-antenna, broadband over power lines. With

deployment of these, the rural community will be able to access ICT services including e-applications over wide area. The idea for architecture is to use citizen-centric approach for rural area. Research and development framework should provide government with low cost possible solutions acting as catalyst. The government then using these low-cost frameworks, outsource the hardware requirements. The collaboration mechanism from international corporations will be an advantage for providing effective techniques in internet connectivity. Furthermore, outsourcing of development and connectivity projects to private corporations will add advantage to public private partnership. This can also be done by examining strategies applied by OECD countries (Organization for Economic Cooperation and Development).It comprise of 37 countries. Mission of this organization is to understand how ICT contribution paves way for sustainable development. It assesses how to promote economic and social wellbeing policies for their people.

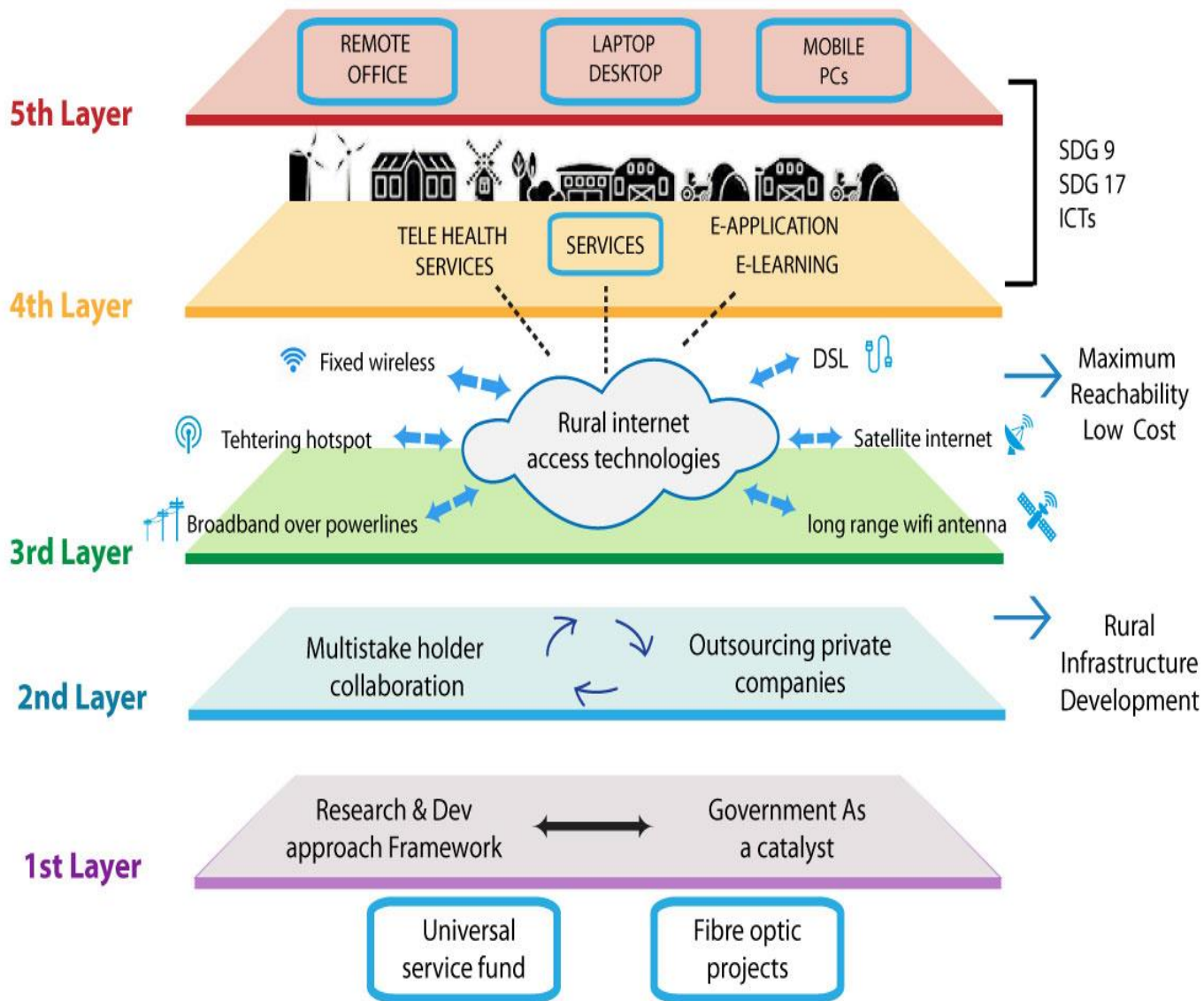


Figure 3.4 Layered Framework Architecture

Chapter 4

4. Conclusion

Considering the challenge of unconnected rural population of Pakistan, we proposed a 5-layered architecture frame work. The layered structure extends vertically collaborating with layer above, thus providing means of making internet available to the maximum people. The dynamics of Internet in Pakistan both wireless and broadband will provide capacity to access e- applications utilized by population living in urban and rural areas. Our proposed solution still faces some challenges, including infrastructure cost, technical equipment, unequal distribution of sources. Additionally, there are some rural areas with geographic constrains where propagation of signals is also another challenge. The 5 layered architecture can be further improved with more interactive discussions and viewing the work done on internet connectivity in other countries. Also, comprehensive strategy with technocrats from field of internet and ICT can provide thorough practical solutions for achieving targets. Moreover, collaborative development plan with low cost, minimal expenditure, maximum reachability is needed. The outcome of paper indicates several issues that need to be address in more holistic manner.

As sustainable development goals are defined, Pakistan is making an effort to bridge gap between people in rural and urban areas, through achieving them. Lack of Internet connectivity to rural sector hampers development in these areas. From the early 1980's, the developed countries started to implement ICT policies for growth in telecommunication and infrastructure. Pakistan being a developing country is still making progress through development initiatives as discussed above. It is in the early stages of adopting tools and techniques for connectivity and ICT in various fields. The paper shed light on methods and approaches adopted by some countries for deployment of broadband and wireless internet services. Pakistan is also aiming at providing its people with internet access with cheap affordable cost and improved services. Although it has not yet achieved the vision 2025, but government, regulatory organizations and NGOs all are working in collaboration with each other to achieve development goals in connecting the unconnected Pakistanis. As vision 2025

and SDG are interrelated with each other, for providing people with internet and ICT services, focus should be on implementing fundamental requirement of connectivity first. Because till 2025 our population growth will be exponential, needing better and robust means of ICT and communication, so measures should be taken into account for that as well.

Chapter 5

5. Limitations and Future Work

The provision of internet is an important factor for rural and urban infrastructure. All the rural and remote societies need access to broadband for economic prosperity. Although this study provides important insight about multi-dimensional challenges of geo, social and economic reachability in Pakistan that hinders internet development. There are few limitations due to which the rural areas are deprived of basic ICT and internet facility. The core of which is physical landscape of Pakistan and its rural areas where resources available are scarce or not available. Further due to lack of collaboration between government and private organizations the major facility of internet is still underserved in far flung areas. Moreover the high cost, low bandwidth, unrepeated signal attenuation delays the provision of internet in hilly and mountainous areas.

The devised framework can be used in future and applied in research and development. For providing internet connectivity to rural areas of Pakistan in order to accomplish sustainable development goals, it is necessary to take measures for improved telecom quality and infrastructure (from copper wires to fibre optic cables). Other modes of internet connectivity including light beam technology, satellite internet, long range antenna can be applied for robust and efficient internet in unreachable and underserved areas.

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