RATIONALE FOR EXPANDING BROADBAND IN BANGLADESH

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Benefits and Costs of Expanding Fixed Broadband Internet

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Rationale for Expanding Broadband in Bangladesh: Cost Benefit Analysis

Bangladesh Priorities

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Introduction

Bangladesh's Internet penetration is primarily dominated by mobile broadband. Of the 63 million Internet connections in the country, 60 million are through 2G or 3G mobile technology (Bangladesh Telecom Regulatory Commission 2016). Additionally the market share of fixed broadband channels (such as wire-line or WiMax) is shrinking (Islam 2015). The future of broadband internet connectivity in Bangladesh is heavily titled towards an environment where mobile plays the dominant role.

According to ITU (2012) research, every 10-point increase in broadband penetration increases economic growth rates, on average, by 1.38 per cent in low- and middle-income countries. A decade back, there were only eight cell phones for every 100 people in the developing world while today there are almost 90, opening opportunities for tens of millions of people who were previously excluded to participate fully in mainstream economic activities (ibid). In this context, the influence of broadband in the overall telecommunication infrastructure in any one nation is important (UNDESA, 2014).

In contrast, Thomas and Garbacz (2011), assert that every 10 percentage point increase in *mobile* broadband household penetration *reduces* GDP per household by 0.52 (significant at the 1% level). The study concludes that this result could be due to nonproductive applications of mobile broadband technology where it might be an uneconomic substitute or complement to existing fixed broadband. Indeed, a recent study undertaken by SQW for UK Government, reviewing more than 100 articles and reports (Mack Smith, 2013), concluded that macro level indicators cannot be used to justify economic growth, without taking into consideration what broadband is actually used for. In the Bangladeshi context, there is some evidence to suggest this issue may be particularly important. Recently on 18 November 2015, the government temporarily banned social networking applications Facebook, Viber and Whatsapp, and the volume of mobile broadband traffic dropped 30% (Ahmed 2015). While not conclusive, it suggests the magnitude of GDP benefit described in many correlation studies may be lower in the Bangladesh context because a significant share of broadband is used for beneficial, but not economically productive activities traditionally captured in GDP.

In any case, the biggest constraint in Bangladesh to unlocking the potential of increased broadband, is not the use of social networking applications but the cost of broadband to the consumer. Current cost of GB per data is ~175 BDT per GB, which is prohibitively expensive, particularly for the majority of the rural population to enjoy the benefits of broadband (Zaman 2015). In this study, we examine several fixed line options that could deliver broadband internet via existing cable TV infrastructure for a fraction of the price – only 500 BDT for 50GB per month.

Based on available data and information obtained from key informants, this study proposes that Bangladesh can significantly benefit to deliver affordable fixed line broadband services, unlocking economic growth in two key areas: 1. Online employment and 2.Agricultural yield growth.

With the assumption that 20 million subscribers consuming 50GB data per month will create the opportunity of 3.6 million online jobs and empower 15 million farming families to benefit from better farming knowledge to increase yields by 10% over 10 years, it appears that Bangladesh can reap USD21 to USD51 billion, conservatively estimated, by making an investment of USD7.8 billion over a period of 10 years, turning cost benefit ratio between 3 to 7.

Additionally, offering 50 GB data at BDT500/month will open beneficial, video centric broadband applications such as online health and education services. Due to deficiency of data, we do not model these benefits, instead noting that our results, by leaving out likely sources of benefit, represent a lower bound on the scale of benefit for Bangladesh.

To attain these benefits, Bangladesh needs to address a key bottleneck of the broadband value chain: address market failure of domestic transmission service. Investment should also be made in content and applications, and promoting opportunities to target users. In short, the major challenge for Bangladesh is to create the right market incentives to reduce broadband price at least by a factor of 30, thereby unlocking growth potential, particularly at the bottom of the pyramid.

The rest of this paper is structured as follows. In Section B, we provide an overview of broadband's rationale within the global and Bangladesh contexts. Section C describes various avenues for fixed line expansion and their costs. Section D makes a case for the types of benefits that may accrue once broadband is available in millions of homes around Bangladesh. Section E provides the results of cost-benefit analysis. Section F concludes and provides policy recommendations for Bangladesh decision makers.

Overview, Background and Constraints

The World Bank's latest World Development Report 2016, titled *Digital Dividends*, made an interesting remark: 'the poorest households are more likely to have access to mobile phones than to toilets or clean water,' (World Bank, 2016: xiii).[1] The *Mobile Economy Report 2015* (GSMA, 2015), based on a survey of 19 countries, indicated that taxes accounted for more than 30% of sector revenue in more than 50% of the markets surveyed, and that in in Bangladesh and Turkey, taxation (handset, subscriptions and services, as well as a number of sector-specific levies on operators), accounted for almost 60% of sector revenue (p. 35). Such high taxes on consumers have serious demand-supply consequences: on the demand side, it restricts access and usage by reducing affordability, while on the supply side, taxes on operators' limit incentives for investment, for example into expanded network coverage.

National Broadband Policy

Research conducted for the Broadband Commission suggested that the introduction or adoption of a broadband plan is associated with 2.5% higher fixed broadband penetration, and 7.4% higher mobile broadband penetration, on average.[2] This result is consistent with the National Broadband Policy 2009 of Bangladesh, focusing efforts across industry in coordination with policy-makers, emphasizing broadband as a national priority, and signaling national commitment to the roll-out of broadband.[3] Initially, the National Broadband Policy focused on broadband roll-out and the Broadband Commission has found that some 88% of Plans include consideration of infrastructure deployment, often including telecom Key Performance Indicators (KPI) to monitor progress (ITU and UNESCO, 2015).

Bangladesh is between the second (adoption) and third (integration) phase (see Table ----). For example, digital literacy programs or community access projects are being implemented with the aim of promoting e-education, e-health, e-commerce and e-governance initiatives. Basic telecom indicators remain important in the second phase whilst the third phase focuses on evaluating the social, economic and institutional uses of broadband.

[1] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2016/01/13/090224b08405ea05/2_0/Rendered/PDF/World0developm0000digital0dividends.pdf

[2] http://www.broadbandcommission.org/documents/reports/bb-annualreport2015.pdf

[3] http://www.btrc.gov.bd/sites/default/files/national_broadband_policy_2009_0.pdf

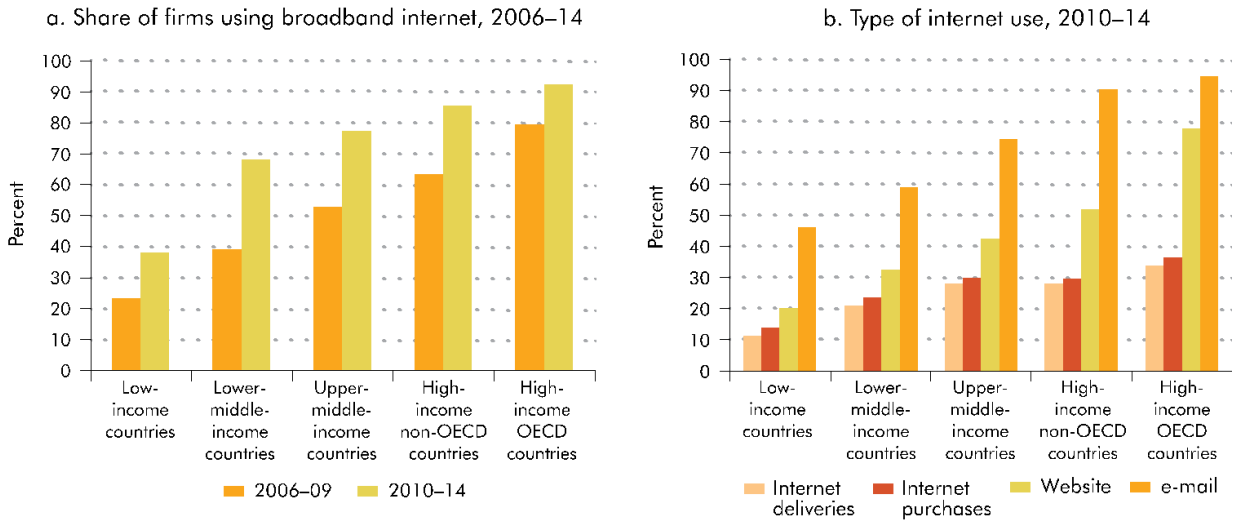
Table ---: Successive Phases of a National Broadband Plan

Phase	1) Deployment	2) Adoption	3) Integration
Focus	Broadband network availability	Broadband access & capacity building for effective use	Broadband integration in economy and society
Examples	Optical fibre cable and wireless broadband access networks	Digital literacy programmes; community access projects & programmes	e-health, e-governance. e-education and e-commerce strategies
Indicators	Telecom indicators	Performance indicators	Outcome/impact measures

Source: ITU and UNESCO (2015: 31)

The WDR 2016 categorized countries in five income groups to depict the share of firms using broadband internet and the type of use into four groups. The Report considered firms with at least five employees and found that use of broadband recorded the highest growth in the lower-middle-income countries. Firms share of using broadband within this country group, of which Bangladesh is a member today, increased from 39 percent to 68 percent from 2006–09 to 2010–14 (see Figure ----). An overwhelming 90% of all firms in high-income OECD countries used a broadband internet connection between 2010 and 2014, with usage rising from 79 percent in 2006–09 to 92 percent in 2010–14.

Figure ---: Firms using broadband



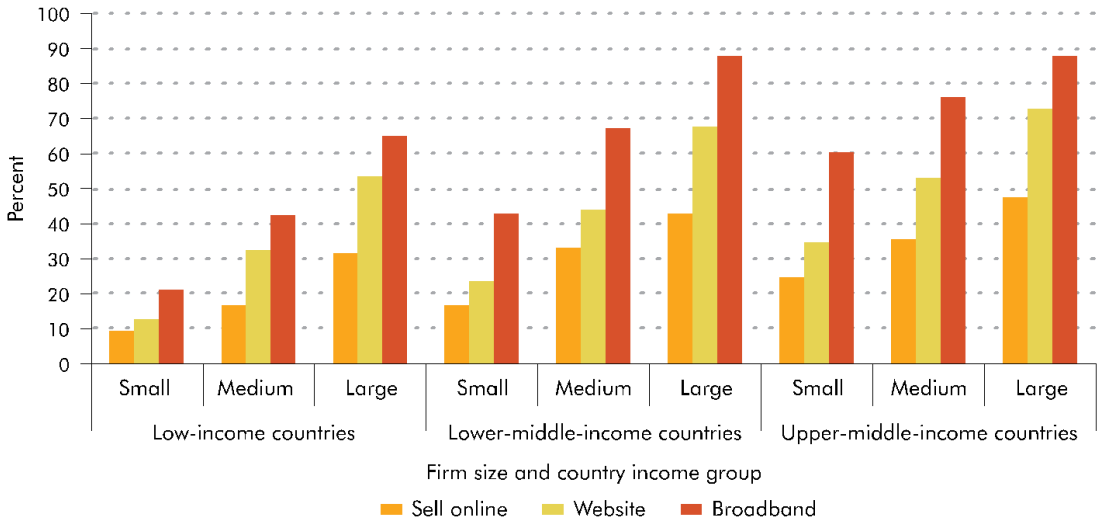
Source: WDR (2016: 52)

With regard to panel b in Figure ----, more than 90 percent and 46 percent of firms, belonging to high-income and low-income countries respectively, used electronic mail (e-mail) to communicate with clients between 2010 and 2014. The differences are greater when Internet is used for more demanding business activities. For instance, 78 percent of firms in high-income OECD countries had a

website, and 52 percent in high-income, non-OECD countries. For the lower-middle-income, nearly 60% of firms reported to have used e-mail, 33% have websites, 24% and 21% made internet purchases and deliveries, respectively. In the last two indicators, firms in lower-middle-income group are not too distant from the countries in the upper-middle-income group – recording 30% internet purchases and 28% internet deliveries.

What is of interest to note here is that what type of firms are using broadband? The WDR 2016 examined this within the context of three income groups taking into consideration small, medium and large firms. Figure --- reveals larger firms' absolute advantage in using broadband across all country groups. In both the lower-middle-income and upper-middle-income groups, 88% large firms reported to have used broadband. The difference is most striking between their small firms with the former recording 43% and the latter, 60%. The differences are also comparable for firms that use the Internet for more intensive business activities: 17 percent of small firms deliver goods or services using the Internet in lower-middle-income countries, compared with 43 percent of large firms.

Figure ----: Use of internet across income groups 2006-2014



Source: WDR (2016: 55)

Challenges

On Upwork (previously oDesk), Bangladesh, India, Pakistan, the Philippines, and the United States reported to have the largest number of contractors in relation to their populations (World Bank, 2016). Nevertheless, high cost of mobile broadband service is constraining Bangladesh from tapping into its freelancing employment potential. The major challenge is to reduce the broadband price, at least by a factor of 30 in comparison to current price of mobile data. To do so, besides mobile broadband, other options such as CableTV, FTTH, FTTx and WiFi needs to be explored to maximize return from broadband investment. It appears that both cost and throughput limitations, particularly constrained

by poor growth in spectral efficiency and availability of spectrum, makes mobile centric data connectivity neither economically viable not technically feasible to serve purposes beyond basic communications, entertainment and social networking.

The major challenge for Bangladesh is, therefore, to take advantage of combining difference technology platforms in a complementary manner to deliver high volume data at high speed, all across the country at the lowest cost. The latter is the key to unlocking broadband's potential in terms of accruing high benefits to Internet users – whether they be freelancers or farmers, agriculture extension workers, teachers, etc.

For example, a freelancer usually requires 60 GB per month to earn BDT10,000 (average earning per freelancer is USD1500/year in Bangladesh), which costs around BDT 10,000 via 3G. Thus, it is important to consider other fixed line broadband options, delivered by Wirleine and WiFi which has the potential of creating job for millions of Bangladeshi youth.

The UNDESA (2014) argued that in order to ensure the full benefits of e-government, the most important factor is improving access to broadband, through both national efforts and international cooperation. The government of Bangladesh will need to explore policy options and platforms for reducing access costs for mobile broadband; support private collaboration for knowledge management and dissemination; encourage innovative business models that will spur employment growth; and, support ICT entrepreneurship. In this paper, we will show that fixed broadband via cable is the most cost effective method for promoting online employment and improving farmers knowledge on best agricultural practices.

Cost of various options to increase broadband penetration

There are three main cost components in delivering Internet data to consumers: 1. International connectivity, 2. Domestic transmission or backhaul, and 3. Access network. In this section, we provide an overview of the most promising options for expanding broadband in Bangladesh.

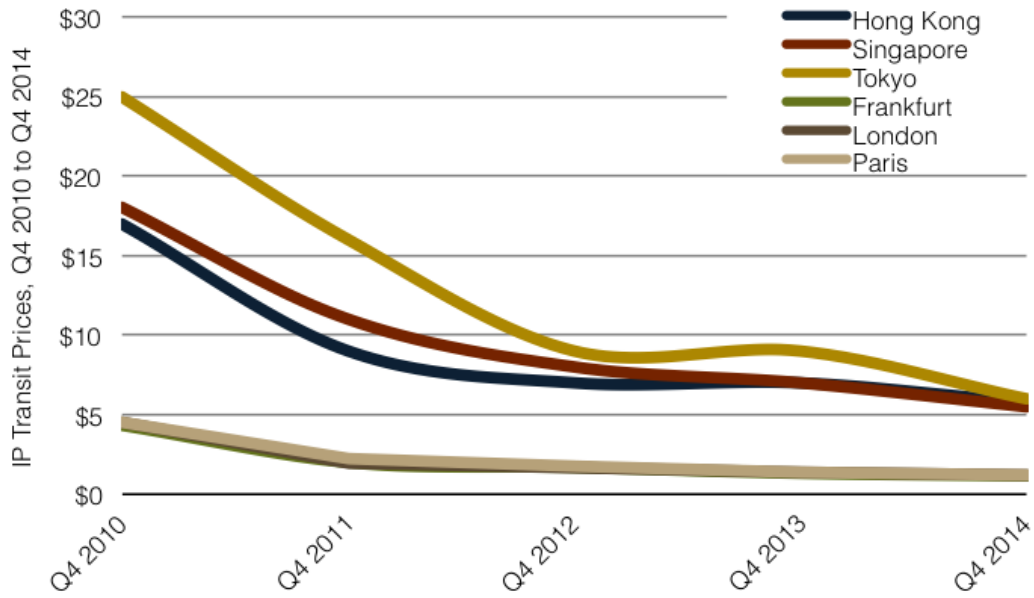
The overall value chain of the broadband service in Bangladesh is shown in Fig. 2.

Figure 2: The overall value chain of broadband service in Bangladesh

International Connectivity

At present, Bangladesh is connected with the global Internet across 7 links: One submarine cable in Cox's Bazar and 6 cross border terrestrial cables, connecting more than a dozen submarine cables landing in Chennai, India. Capital expenditure for each terrestrial links is estimated to be USD5 million. Bangladesh signed a deal with SEA-ME-WE-5 consortium to access 14,000 Gbps capacity, costing USD70 million[4]. In addition to this capital expenditure, international connectivity providers are required to pay for IP transit to global telecom players. With rapidly decreasing IP transit price[5], current payment obligation is around USD5 per Mbps for connect Bangladesh's international gateways to global networks, via Singapore, as shown in Fig. 3 (Telegeography 2015).

Figure 3: Trend of IP Transit Price Source: Telegeography



Domestic Transmission

Domestic transmission network is a vital component to connect to international gateways. At present, domestic transmission cost constitutes a significant component of providing Internet connection, particularly outside Dhaka. In certain cases, 1 Mbps link connecting Dhaka and Rajshahi could be as high as BDT5,000 per month. An investigation into cost components will enable us to gain a better understanding of the scope for reducing per unit transmission cost.

[4] http://www.dhakatribune.com/technology/2014/mar/08/bangladesh-signs-deal-join-2nd-submarine-cable
[5] https://www.telegeography.com/press/marketing-emails/2014/09/24/ip-transit-price-declines-slow-globally/

According to project data of BTCL, for connecting 290 upazilas (sub-districts) with the national gateway costs USD60 million, resulting in USD100 million for connecting all upazilas. On the other hand, estimated cost, according to BTCL's project cost estimates, for connecting 4,500 union parishads to 487 upazilas is USD450 million (USD100 million for connecting 1,000 unions). Moreover, BTCL invested around USD100 million in developing the national fiber optics backbone connecting all 64 districts. Therefore, it could be said that cost of transmission connecting all unions to international gateway is almost USD550 million. If we estimate that this cost will be distributed over 100 million customers, average cost for connecting each customer is USD5.5, which will be amortized over a span of 20 years.

To benefit from competition, Bangladesh has also issued license to two private operators. Assuming that these operators will eventually build nation wide transmission network, the total cost for domestic transmission will be around USD1.5 billion.

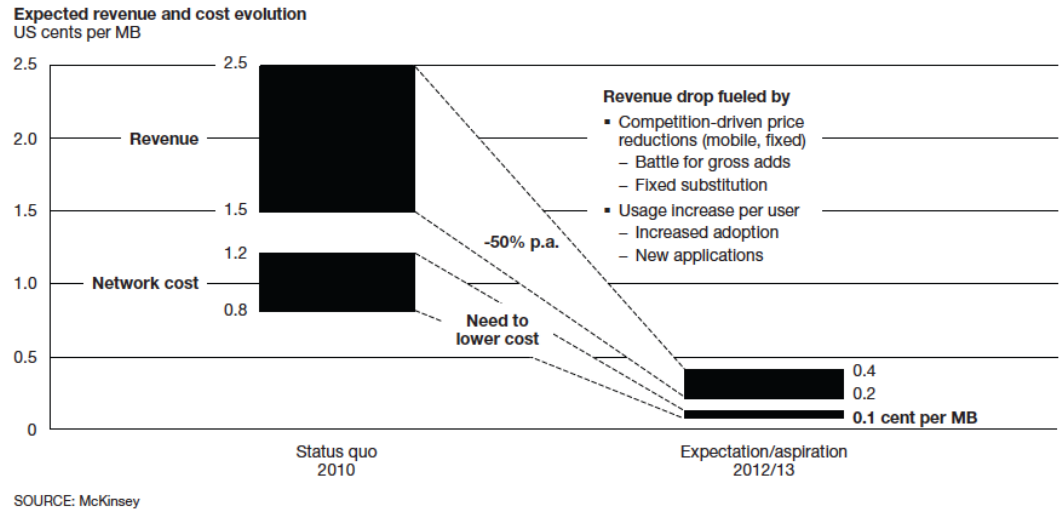
Access Network Service (ANS) Operators

ANS operators are at the distribution end of the value chain providing end user centric services. There are several major categories of ANS providers, as explained below.

Mobile

There are many cost components associated in estimating cost of production of mobile data. Mobile broadband service to users constitutes 95% of cost. Cost of production of mobile data using 3G is around USD1/GB, equivalent to BDT80/GB (Jeroschewski 2013). At present, the dominant operator GP has been charging BDT275 for 2GB data. Although other mobile operators charge less than GP's rate, it is difficult to explain why almost 16 million users prefer GP's service. With these 2GB data, only basic communications can be supported and due to the high cost, video centric applications of broadband using mobile connectivity have not become popular yet to the mass population, particularly for those living on BDT43 per day (extreme poverty). Although price has been falling, it appears to be above BDT80/GB as shown in Fig. 4. Such costly solution, in spite of the mobility uniqueness, will likely remain limited to support basic communications such as e-mail, voice over IP, social media, videos (e.g. for agriculture workers, community health workers, etc).

Figure 4: McKinsey's cost estimation for production of mobile broadband services (Jeroschewski 2013)



SOURCE: McKinsey

Ethernet LAN

Among wire line operators, Ethernet LAN based service is dominating the ANS operations in Bangladesh. Almost 95% of 1.5 million wireline subscribers are accessing broadband using Ethernet LAN. It has been learned that almost 80% of costs are added in distributing broadband connection to end users. Due to steady growth of other cost components, it appears that cost of offering end user level connectivity using Ethernet LAN will not experience any decline in the near future.

ADSL

In contrast to most developed and developing nations, ADSL penetration in Bangladesh is extremely low. Among 1.3 million wireline subscribers, only 20,000 are using ADSL. Although ADSL could have proven to be one of the least cost options, slow response of incumbent wireline operator, BTCL, deterred its uptake and growth.

FTTH

This is also similar to the ADSL's usage level.

FTTX

FTTX has been gaining popularity among all types of broadband service providers and even among CableTV operators. Basically, connectivity between PoP of transmission network to distribution point of ANS operators is being installed as fiber optics cable. From distribution point to end users' devices, different technologies such as twisted copper wire, radio frequency (for mobile or WiFi), or coaxial cable are being used.

WiMaX

Despite early success of two WiMax operators, its subscription has been steadily decreasing reaching to less than 200,000 in 2015. It is to be noted here that WiMax operators are moving to deploy LTE under a new modified licensing condition.

Scope of Providing Broadband at Minimum Cost

In order to tap into the potential of those working in rural areas and requiring tailored information and services, we have to deliver video centric broadband services. Such broadband service needs to deliver huge amount of data to each user, which could easily reach 50GB per month per user, as opposed to current consumption of around 300MB data by mobile broadband users. And we need to deliver such huge data at a price of BDT500/month to make it affordable for the target users. To achieve this target of offering volume data almost 150 times lager than what is being consumed by mobile users, at a price as low as BDT10/GB which is almost 30 times lower than current mobile data rate, we need to explore other alternatives.

We need to examine options for taking advantage from economies of scale and scope for example, through offering three basic services such as CableTV, Internet, and Phone over the same network. As CableTV has the highest penetration among all wireline services, we need to consider options of using its network to offer such huge amount of data at possibly the lowest cost. Moreover, private CableTV operators are already running their network at profit just offering one service CableTV, charging very low monthly fee of BDT200/month in rural areas and BDT300/month in urban areas. Most of these CableTV operators have also developed fiber optics backbone and some of them are in process to replace last mile coaxial with fiber optics cable.

CableTV

As wholesale bandwidth price has come down to less than BDT500/Mbps, so at 25 contention ratio, 4Mbps connectivity will consume only BDT 80 of international bandwidth. With an estimated five years of working life of electronic devices (router and CPE), cost for equipment per customer on a monthly basis will stand to be BDT260 (interest has not been added). Thus, cost of delivering 4 Mbps will be only BDT 340/month. Such connectivity will deliver 52 GB data for at least two-hour videos every day--which appears to be basic need to address those above 5 opportunities. By adding BDT 100 for domestic transmission, which is a challenge to meet, and BDT 60 profit for providers, 4 Mbps connectivity at a contention ratio of 25 could be offered to families at a monthly rate of BDT500, over the existing CableTV network.

Recommendation for Addressing Domestic Backbone Service Market

Domestic transmission appears to be the main bottleneck facing Bangladesh to create affordable, high-speed access network for broadened services. The Government appears to be caught between rock and hard place to make progress to expand domestic transmission infrastructure to connect rural Bangladesh to Governments' Digital Bangladesh initiatives. On one hand, it cannot encourage private investments, primarily from private NTTN operators, to justify large sum of long-term investment, when future market potential to generate profitable revenue from rural Bangladesh is impossible to foresee. On the other hand, Government's reliance on BTCL, state-owned company, to expand the transmission infrastructure in rural area, with the support of state sponsored finance and grant, runs the risk of market distortion. Moreover, historical weak operational performance and slow progress in large-scale project implementation place the Government at cautionary position to rely on BTCL--to lay the foundation for implementing such an important political commitment. Recent example of foot-dragging of BTCL related to USD25 million soft loan to expand the domestic transmission makes the apprehension of likely non-performance more intense. High investment need and long payback period are also encouraging private operators to deploy overhead fibers, instead of underground, which runs the risk of frequent backbone failure leading to unreliable communication services. Instead of being paralyzed, Government needs to carefully compare policy options to deal with this quandary.

Most of the countries of the world have taken massive initiatives to roll out nationwide fiber optics backbone infrastructure. In India, Government is expanding the fiber optics backbone infrastructure to connect 250,000 village councils at a cost of USD 4 billion. From global context, government responses to the market's need for nationwide fiber optics backbone deployment have taken three distinct forms: 1. Driver Governments (e.g., Japan, South Korea, Singapore and India), policymakers have chosen to drive the process actively, 2. Facilitators Governments (e.g., Sweden and Norway), have chosen to facilitate private-market solutions, and 3. Observer Governments (e.g., USA and Germany), have chosen to step back and observe market challenges and jump in only when absolutely required. The vertical segmentation allows analysis of options for the Government to decide about segment specific appropriate response, as shown in following Table.

Table V: Multi Layer Business Models

Vertical segments	Typical elements	Proportion of investment	Scope to benefit from competition	Typical payback period
3. ServiceCom	Applications and Contents	10%	High	2-3 years
2. ActiveCom (Capacity)	Light Sources, Switches and Routers	20%	Medium (Oligopoly)	5-7 years
1. PassiveCom (Facility or Infrastructure)	Ducts, Dark Fiber, and Power	70% (including right-of-way)	Low (Regulated Monopoly)	15-20 years

Source: Adapted from Ofcom Next Generation Access (NGA) consultations and local stakeholder consultation (cost of access network is excluded)

1. **PassiveCom:** The most capital-intensive, but also faces the least competition due to high economy of scale benefit, may be considered as public good. Policy options for the Government to influence this segment, as driver, are as follows:
    a. Through competitive bidding among public and private operators, provide soft loan and grant to winning bidders to develop and operate such passive facility.
    b. The country could be divided into different geographical segments to ease the complexity of project implementation, resource mobilization and maintenance. Participation of a single firm in multiple geographical areas should be limited. Moreover, interconnection should be regulated to connect different segments into a unified single nationwide infrastructure.
    c. Split NTTN license into two: 1. Facility service provider, and 2. Capacity service provider.
    d. Issue license to new backbone facility service providers to ease both financial and technical capability to deal with such huge infrastructure development.

To allow price regulation, and ensure quality of service and fair competition, PassiveCom of the business must be structurally separated from other businesses of winning companies—whether public or private.

2. **ActiveCom:** As observer, Government should ensure fair competition in leasing facility by capacity service providers, whether private NTTN operators or BTCL, to provide active transmission capacity to Access network operators such as ISPs, or MNOs. Government should issue additional NTTN licenses to increase competition in capacity services.

3. **ServiceCom:** As facilitator, Government should invest in R&D, promote innovations and be lead users of citizen centric, bandwidth intensive services (e.g., e-Health, e-Agriculture, e-Governance).

Given the stake, a challenge therefore is that policymakers are fully informed about the scope of segmentation to reduce barrier and increase competition, potential to benefit from technology dynamics by strengthening market forces, and asymmetric role of the Government in different segments to address market failure in the telecom backbone--while avoiding creating policy uncertainty which itself holds back competition.

Untapped Potentials of Broadband Centric Economic Growth and Barriers

Beyond macro-studies that focus on the correlation between penetration and GDP (see e.g. Minges, 2016 for a review), the evidence of the benefits of broadband in the developing country context is limited.

That said, there is strong theoretical and empirical evidence that increased access to information, increased productivity through more efficient process and increased market access – all features that are likely to be delivered by broadband – provide substantial benefits to an economy and its composite sectors (e.g see Katz, 2012 for an overview of the main pathways upon which broadband improves an economy). In particular, the literature on ICT use on outcomes in agriculture, education and health is suggestive, albeit not definitively, that broadband (which would enable better technology than that analyzed by ICT studies) could provide benefits to the Bangladeshi population in certain circumstances.

In agriculture, Nakasone, Torrero and Minten (2014), reviewing the literature of ICT use in agriculture, provide evidence that the use of cell phones to access market information has had a general positive impact on farmers, at least at the macro level, though at the micro-level there is conflicting evidence. For example, Peruvian farmers in villages with mobile phone coverage increased their household consumption by 11% between 2004 and 2009 (Beuermann et al., 2012) and Keralan fishermen experienced 8% profit jump when mobile phones were introduced to that state (Jensen, 2007). However, in Niger, Aker and Fafchamps (2014) show that farmers selling cowpeas and millet did not enjoy better prices when provided with cell phones.

While price information can easily delivered by broadband, it is likely that this benefit has already been taken, if it indeed exists in Bangladesh, by low-tech 2G services such as SMS. The greatest potential for benefit, therefore, is in the enabling of increased video-based knowledge sharing, directly between farmers or via the 13,000 extension workers in Bangladesh, where broadband would represent a significant technology jump over existing ICT application. In terms of empirical evidence, two studies show that low technology options – call centers and mobile phones that enable very short videos to be shared - have helped improve extension services (Fu and Aker, 2012) or farm practices such as pesticide use and choice of crop (Cole and Fernando, 2012). This is suggestive that broadband enabled video services, which would allow higher quality information to be shared, would also lead to improve farming practices. The studies mentioned, however do not measure nor report the magnitude of the yield / profit improvement arising from these services. Given the average current yield gap in Bangladesh is 30% (Miah 2015, p.23), there is reasonable scope for modest improvements in yield arising from improved broadband enabled extension services of 2.5% to 5% total over 10 years.

Better broadband would also enable numerous Bangladeshis, particularly youth, to participate in the global freelancing and 'microwork'[6] market, with 48m workers is valued at nearly $2bn globally (2013 figures). Workers in the developing world currently capture a significant share of the market with the largest players - India, Philippines and Pakistan holding 46% of the global market. The total freelancing and microwork market is expected to grow to $15-$25bn by 2020 and support part-time work for more than 112m workers by 2016 alone (Kuek et al.,2015). Given the nascent state of the industry, academic work on online freelancing is scant. However, Bangladesh appears reasonably well positioned to take her fair share of this market, with leading freelancing site e-lance noting Bangladesh as not only a top 10 country in terms of revenue, but one of the countries with 25%+ growth in earnings on its platform in 2014 (elance, 2015). Online work appears to have the backing of the government, insofar as the National Bureau of Revenue officially deems freelancing work tax-free. Additionally, Bangladesh has an advantage in that English, the lingua franca of the Internet, is relatively more common than in potential competitor countries (Kuek et al., 2015). Cheap, reliable broadband would enable a greater share of Bangladesh's 15-24 year old population, 9% of whom are unemployed (World Bank, 2015), to access this lucrative, growing market. In countries with the greatest proportion of online workers, the share of the population working online is 1%-2% (Kuek et al. 2015). If

[6] 'Microwork' consists of short tasks taking several seconds or minutes each. While the market for this is only 10% the size of the freelancing market (longer, more complex jobs) the barriers to entry are small, requiring only basic literacy and numeracy skills. Kuek et al (2015) report that 75% of freelancing workers have a university degree, compared to 33% for microworkers.

Bangladesh achieves a similar level, it will have 1.8m-3.6m online workers by 2025, and likely much more if one assumes the industry will expand tenfold to $15-$25bn from current size of $2bn as reported in Kuek et al. (2015).

In the field of education, there are a handful of high quality studies, which estimate the impact of ICT on learning outcomes. The results suggest that the exact application of ICT in the classroom context and program design appear to be particularly important. In Colombia, students provided with computers in the classroom (Barrera-Osorio and Linden, 2009), exhibited 1SD (standard deviation) improvement in test scores. Banerjee et al. (2007) test the effects of a government Computer Assisted Learning (CAL) Program on learning outcomes for 55 primary schools in Vadodora, India. They find that 2-hour weekly computer based lessons improved math test scores by 0.35SD in the first year and 0.47SD in the second year, relative to a control group, while having no effect on language tests. In Peru, a laptop scheme had no effect on learning outcomes (Cristia et al, 2012). It is difficult to understand from simple comparative analysis of these studies, what may have driven this difference. However, a study by Linden (2008) sheds some light: the study tested the effects of the same government CAL Program studied in Banerjee (2007) but on learning outcomes for 60 schools in Western India. In this study the authors varied the method of learning – for one sub-group students were pulled out of normal class to receive a one-hour computer learning session. In another sub-group students were given an hour of computer based learning *in addition* to the normal curriculum. The students who were given extra CAL classes achieved math test scores 0.28SD higher than the control group. However, those who were taken out of normal class achieved test scores 0.57SD *lower* than the control group. The implication is that program design matters when considering the effects of ICT on education outcomes.

Would cheaper broadband have positive effects for education in Bangladesh? Online video tutorials, delivered via streaming broadband could supplement the learning outcomes of up to 40 million students who go to school in modestly funded, ill equipped and poorly staffed academic institutions. However, given that the evidence is entirely from the use of computers, not broadband per se, and the clear sensitivity of effects to program design, we leave out education from the analysis and note that any benefits, if they exist, would imply that the BCR reported in this study is conservatively estimated.

The final category for consideration is in health, where most of the research on the effects of broadband has been conducted in the developed world context where both the necessary ICT and health infrastructure are present to (theoretically) deliver benefits in the health sphere.

However as with agriculture, the evidence in the developing country context only relates to basic ICT, in particular mobile phones. Mobile telephony seems to be playing an important role in terms of implementing a variety of health interventions (e.g. D.Net's MAMA program in Bangladesh). The WDR 2016 observed that m-Health interventions are being implemented to address supply side issues, such as point-of-service data collection, disease surveillance, health-promotion campaigns, telemedicine, etc. On the demand side, citizens, such as SMS reminders to parents to get children vaccinated or to patients to undertake therapy. Agarwal and Labrique (2014), based on results from pilots in Bangladesh, India, South Africa, and Tanzania, argued that regular SMS communication can induce similar behavior changes in expectant mothers by providing information on neonatal health. The initial results are also promising from m-health initiatives that assist health providers in recording patient information, monitoring pregnancies, and reporting drug stock-outs.

These results from basic SMS technology are suggestive that broadband could unlock large benefit for Bangladeshi citizens in many areas. However, even in developed countries the full value of e-health has yet to materialize. For example the Australian e-health system (called the PCEHR, or Personally Controlled Electronic Health Record) was previously plagued by low take up and implementation delays (PCEHR internal review, 2013). Given these uncertainties, and the myriad challenges with the Bangladesh health system currently, we do not include these benefits in our assessment.

Barriers to Unlock Economic Growth Potentials

It seems that broadband services, which matter to these farming families, either to generate income, save money, or get meaningful services, are video centric, which require large bandwidth. Although e-mails or Facebook, requiring much less bandwidth than video intensive applications, are useful, their implications on earning or saving capability of these families is negligible. An acceptable quality video to serve those four major applications, required by these farming families, requires at least 2Mbps speed. At this speed, even 2 hour consumption per day will lead to consumption of 54 GB data per month. At current market price, such 54 GB data from GrameenPhone 3G services will cost (@2GB/350 taka) BDT 9,450. This cost for cellular data is certainly beyond the affordable limit of these families, and much more than the target of UN broadband commission: less than 5% of monthly income. It does not allow these families to exploit potential of broadband services to improve their socio economic condition through these possibilities.

Cost Benefit Analysis

In addition to basic communication, direct economic benefits, primarily at the bottom of the pyramid, will originate from areas as shown in Table II.

Table II: Targeted benefit areas from broadband

Target usages	Target users	Estimated users at the end of 10 years	% of total population in 2025 (180 million projected)	Benefit	Benefits per year in 2025, USD, billion	As % of expected GDP in 2025 (USD 180 billion)
On-line Jobs	40 million future job seekers	1.8-3.6 million	1-2%	1300 to 4077 USD per user / year	USD 4-10 billion	1.2-3.0%
Better extension services delivered by broadband	15 million farming families	15 million	8%	5%-10% total yield growth/user family	USD 1-2 billion	0.3-0.6%
Education	40 million students	Unclear	Unclear	Unclear	Unclear	Unclear
e-Health	All population	Unclear	Unclear	Unclear	Unclear	Unclear

As stated previously, in 2013, the leading countries (Philippines, Serbia, Croatia, Romania, Canada and the US) had between 1%-2% of their total population working online (Kuek et al. 2015). We assume that in the medium run (10 years) Bangladesh will be able to achieve similar levels. Given that Bangladesh is currently a top 10 source country according to Upwork (e-lance, 2015), the industry is predicted to experience rapid growth in the foreseeable future (Kuek, et al., 2015), and Bangladesh's population profile has a disproportionately large percentage of men aged below 25 (the most likely profile for online workers is men aged 35 and under) this level seems achievable by 2025. For our cost-benefit calculations we assume linear growth towards the 1% (low scenario, 1.8m people) or 2% (high scenario, 3.6m people) levels of online workers.

Working online is typically not a full time job. Kuek et al, 2015, indicate that 50% of online workers work between 0-20 hours per week, 31% work 21-40 hours per week and only 19% work what would be considered 'full-time' – namely, 40 hours or more per week. We apply these same ratios to the expected Bangladeshi population of online workers, taking the point estimate of 10 hours (casual), 30

hours (part-time) and 40 hours (full-time) respectively as the assumed working hours per week, for our low scenario. Given the rapid expected growth in the industry, we also consider an alternative high scenario, where 25%, 50% and 25% of online users work casual, part-time and full-time respectively.

Some of these online workers would substitute regular work for online work, so it is important to consider the gains from online work as the wage delta, not the absolute value. For the least active users working 10 hours, we assume that all of these workers are doing online work to supplement rather than substitute existing income, if any. For the most active workers working online 40 hours, we assume that this completely substitutes a typical 'off-line' job, which returns a wage equal to GDP per capita ($1235 USD), adjusted to account for the youth jobless rate of 9.1% (World Bank, 2015) or $1123 USD annually. For the part-time, working 30 hours per week, we assume that 75% of them are *substituting* a full time off-line job, and 25% of them are *supplementing* some other work (or would not have a job otherwise).

The last parameter to be considered is the average hourly wage. Kuek et al. 2015 report a typical working wage of $5/hour. We conservatively apply 50% of this rate, $2.5 / hour for the cost-benefit analysis presented here.

Table III: Estimated annual benefit from online work

Category of workers	Annual salary from online work	Counterfactual (substitution from off-line work)	Benefit of online working	Weighting (Low scenario)	Weightin g (High scenario)
Casual 10 hours / week	$1,300	$0	$1300	50%	25%
Part-time 30 hours / week	$3,900	$842	$3058	31%	50%
Full-time 40 hours / week	$5,200	$1123	$4077	19%	25%

Average weighted benefit (low scenario) = $2373 per user / per year

Average weighted benefit (high scenario) = $2873 per user / per year

For the agricultural benefit, we assume an average 5% to 10% **cumulative** additional yield growth (linearly applied) over 10 years, from better agricultural practices brought about by increased knowledge sharing via broadband. Given that the estimated agricultural output is $20billion per year

(BBS, 2015), in 2025 we expect additional output valued at 1bn to 2bn per year or roughly $66 to $132 per farming household per year.

Under these generally conservative assumptions, and ignoring benefits in other fields such as education, health and general productivity improvements, broadband can be expected to have an additional benefit of around 5bn to 12bn or 1.5% - 3.5% GDP boost by 2025.

Major cost components and their estimated value are shown in following Table IV.

Table IV: Cost components and estimated values for expansion of wire line broadband

Sl	Cost components	Cost Estimations and assumptions	
		CAPEX	OPEX[7]
1	International Terrestrial Cables (for 6 operators)	USD 30 million[8]	USD 5[9]/Mbps and 20% of CAPEX
2	Submarine Cables (for 2 cables)	USD 120 million[10]	USD 5/Mbps and 20% of CAPEX
3	Domestic Transmission (for 3 operators)	USD 1500 million[11]	20% of CAPEX per year
4	Access network, primarily based on wire line network to offer triple play services	USD 200 per user, for backend and customer premise equipment (CPE)[12] It has been assumed that initial cable laying cost will be covered for CableTV services	20% of CAPEX for backend and CPE
5	Applications and contents	USD 100 million (one time)[13]	USD 20 million every year

[7] Based on available industry data, documented in different literature
[8] Based on review of project proposal for raising finance for a typical ITC provider
[9] In reference to Telegeography data
[10] Based on news release provided by the Bangladesh submarine cable company (USD40 million for the 1st and USD80 million for the 2nd submarine cable)
[11] Based on review of BTCL project documents, it's estimated that for single network up to union level will cost USD500 million. For three networks, including private two NTTN operators, cost will be USD1500 million
[12] Based on market data obtained from an operator
[13] Based on key informant interviews

Some of the assumptions used in the cost benefit analysis are as follows:

COSTS

1. Investment of USD 1500 million for transmission will be divided over 10 years, in equal installment
2. 2 million high speed customers will be connected to the network
3. Backend cost for each customer is $100, CPE cost for each customer is also $100
4. 20% of cumulative CAPEX is estimated for maintenance, including upgrading of active components
5. Per user data consumption will be @54GB per month, requiring 0.16 Mbps/User
6. Every year 20m USD will be invested to upgrade content and application

BENEFITS

7. The number of online workers will reach 1% (low scenario) or 2% (high scenario) of total population by 2025, increasingly linearly from 0 over 10 years
8. Each online worker will earn between $2373 to $2873 USD per year on average (see Table III)
9. Each farming family, on average, will deliver a boost of 5% to 10% cumulative over 10 years additional yield growth from better extension services and agricultural knowledge delivered by broadband

Based on such assumptions and available data, cost benefit results are presented in Table V.

Table V: Cost benefit of expansion of fixed broadband in Bangladesh

	3% Discount			5% Discount			10% Discount		
	Benefit (USD million)	Cost (USD million)	BCR	Benefit (USD million)	Cost (USD million)	BCR	Benefit (USD million)	Cost (USD million)	BCR
Low Benefits Scenario	24,343	8,568	**2.84**	21,791	7,838	**2.78**	16,835	6,402	**2.63**
High Benefits Scenario	57,011	8,568	**6.65**	51,035	7,838	**6.51**	39,427	6,402	**6.16**

The analysis shows that depending on assumptions, investment into fixed broadband infrastructure would provide benefit cost ratios from **2.63 to 6.65**. This represents the cost of connecting 20 million subscribers consuming 50GB data per month leading to the creation the opportunity for up to 3.6

million online workers, empowering 15 million farming families to benefit from better farming knowledge to increase yield by 10% and potentially improving education and health outcomes. The potential benefit is as large as 51bn discounted at 5%.

To attain this benefit, Bangladesh needs to address the key bottleneck of the broadband value chain: addressing market failure of domestic transmission service. Investment should also be made in content and applications and also promoting opportunity to target users. It is interesting to note that additional 20 million wire line subscribers, will lead to growth of penetration of almost 12.5%, having a likely economic impact in the high scenario of USD12 billion per year by 2025, equivalent to 2.80% additional GDP with increase of 10% increase of penetration, which is in line with the finding of a study done on Latin American and Caribbean (LAC) countries to assess impact of fixed broadband (Zaballos et al, 2012). This study found that a 10 percent increase in fixed broadband penetration triggered an average increase of 3.19 percent in per capita GDP**.**

Overall Summary and Recommendations

Observation 1

Despite the high growth of mobile centric broadband penetration, the high cost of production of mobile data is an insurmountable barrier to unlock economic growth potentials, primarily at the bottom of the pyramid, which demand video centric broadband applications.

Observation 2

Due to limited usage of data as low as 300MB/user, primarily supporting basic communication and social networking, there has been very weak linkage between broadband penetration and GDP.

Observation 3

Primarily usage of conventional correlations between broadband penetration and GDP growth is inappropriate within the context of Bangladesh. With the given usage pattern and recent finding of implications of mobile broadband for non-productive usages, likely economic outcome of mobile centric broadband penetration in Bangladesh on economic growth is questionable.

Possibility

But there appears to be significantly large economic growth potential--as large as USD51 billion over 10 years-- primarily at the bottom of the pyramid, if 50GB data could be delivered at BDT 500/month, which could be attained by taking the advantage of both economies of scale and scope benefit of wire line infrastructure.

Recommendation 1

To tap into economic benefit of USD51 billion with an investment of USD7.8 billion over 10 years, Bangladesh needs to address market failure at the domestic transmission service market.

Recommendation 2

Moreover, Bangladesh needs to make an investment in content and applications and awareness creation to create market for profitable competition of content development and commercialization.

There appears to be significant investment opportunity for Bangladesh, to achieve cost-befit ratio of 7 with a discount rate at 5%, for upgrading broadband by making USD7.5 billion investment, to unlock economic growth potential at the bottom of the pyramid. Such opportunity of generating additional USD51 billion economic benefit over 10 years by expanding wire-line broadband penetration to 20 million households equates to 2.80% additional GDP with the increase of 10% increase of penetration, which is very much in line with some best performing demonstrations of high speed fixed broadband expansion in different parts of the world.

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