Fast Broadband Deployment in India

What role for cable television?

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Abstract

India faces numerous potential challenges in achieving ubiquitous deployment of broadband, to say nothing of ultra-fast Next Generation Access (NGA). As in many developing countries, the current deployment of the fixed network is weak, corresponding to just 3% of the population. The reach of cable networks is three to four times greater, but much of it is old analogue technology. What role could and should cable play in the ultimate build-out of conventional broadband, and of NGA? What respective roles would the fixed network, cable, and wireless in a balanced and technologically neutral deployment?

In several proceedings, the Indian telecommunications regulatory authority (the TRAI) and the Ministry of Information Broadcasting have recognised the importance of modernising the cable plant to make it both digital and addressable, and to enable cable to take its part in broadband deployment. What impediments exist? How likely are these plans to achieve their goals? What are the implications for public policy?

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1 Introduction

India is large and, in many respects, technologically sophisticated country;[1] nonetheless, it has a far lower penetration of fixed broadband network access than many of its global competitors. As the Indian TRAI (regulatory authority) notes in its "Recommendations on National Broadband Plan":[2] "The broadband growth has not only been slow but also biased in favour of urban areas. More than 60% broadband subscribers are in the top ten metros … Just 5% of the broadband connections are in rural areas which is meagre … In comparison, Internet services through nonbroadband connections have penetrated well in smaller cities in towns …" Clearly, much work remains to be done if India is to achieve high penetration of broadband Next Generation fibre-based Access (NGA) or, for that matter, of conventional broadband.

Among developing countries, the mobile network typically develops more rapidly than the fixed. In India, this is particularly extreme – in a country with a population of 1.2 billion, the number of fixed telephone lines corresponds to just 3% of the population! Moreover, these 34.9 million lines are primarily restricted to urban areas – with only 8.9 million rural lines; there is very little reach into the countryside.[3] At the same time, the number of mobile subscriptions in 2011 corresponds to 77% of the number of inhabitants, and is expected to grow to 91% of inhabitants in 2012.[4] For *voice* services, then, India is rapidly approaching full coverage, thanks to popular and ubiquitous mobile services. Can the same be said of broadband *data* services?

Mobile services are obviously capable of supporting data, and the uptake of these data services has been increasing rapidly in both developed and developing countries. For areas of low subscriber density, this is an ideal solution, especially as mobile networks evolve to advanced data-friendly technologies such as LTE. The bandwidth available within a cell, however, is necessarily shared among users within that cell, which means that mobile is inherently ill-suited for high bandwidth services in high density areas (and thus especially ill-suited for densely settled areas of Mumbai, Delhi or Kolkata).

Most countries that have considered ubiquitous broadband build-out have assumed the need for wired solutions in metropolitan areas, and wireless solutions in the sparsely settled countryside.[5] ADSL solutions are widely understood to be a cost-effective means of achieving basic broadband where the copper-based fixed network is up to the job, and many experts

[1] Indeed, with the number of Internet users fast approaching 100 million, India is said to have the third largest Internet user population in the world. Hindustan Times, "India now third biggest internet user", 14 December 2010, at: http://www.hindustantimes.com/India-now-third-biggest-internet-user/Article1-638366.aspx. Nonetheless, penetration as a percentage of population remains low.

[2] December 2010, at:
http://www.trai.gov.in/WriteReadData/trai/upload/Recommendations/124/Broadbandrecommendationl.pdf

[3] As of February 2011. Indeed, most lines in India were only laid in the last fifteen years. The source of the data is a press release of the Indian TRAI at
http://www.trai.gov.in/WriteReadData/trai/upload/PressReleases/816/Press_release_feb%20-11.pdf.

[4] Merrill Lynch Quarterly Wireless Matrix, January 2011.

[5] The National Broadband Network (NBN) in Australia, for instance, intends to servce 90-93% oft he population with FTTH/FTTB solutions, the remainder with wireless or satellite solutions at lower speed.

have found VDSL/FTTN solutions, which likewise take advantage of the existing copper loop to the customer premises, to be the most cost-effective means of delivering ultra-fast broadband in suitable dense metropolitan areas.[6] For India, however, there is a "hitch"with ADSL and VDSL – one cannot take advantage of cooper loops that were never deployed in the first place! The penetration of the fixed network in India is, as previously noted, quite weak, both quantitatively and also in terms of the quality of the copper loops. How, then, should India most appropriately seek broadband deployment in dense areas?

India possesses a quite enormous potential asset that is often overlooked. A very substantial number of Indian households (variously estimated at between 80 and 140 million households)[7] subscribe to cable television. Indeed, the penetration of pay TV is 78%, and some 70% of this is cable.[8] Modernised cable television, particularly when upgraded to support DOCSIS 3.0, is a worthy competitor to fibre-based NGA. Where cable is already physically available, cable broadband generally can be implemented at a substantially lower initial deployment cost than fibre-based NGA. In most countries, cable network operators are motivated to upgrade their systems at their own expense, without the need for any public policy intervention, solely based on the business case of additional broadband or triple play (video/data/voice) revenue.

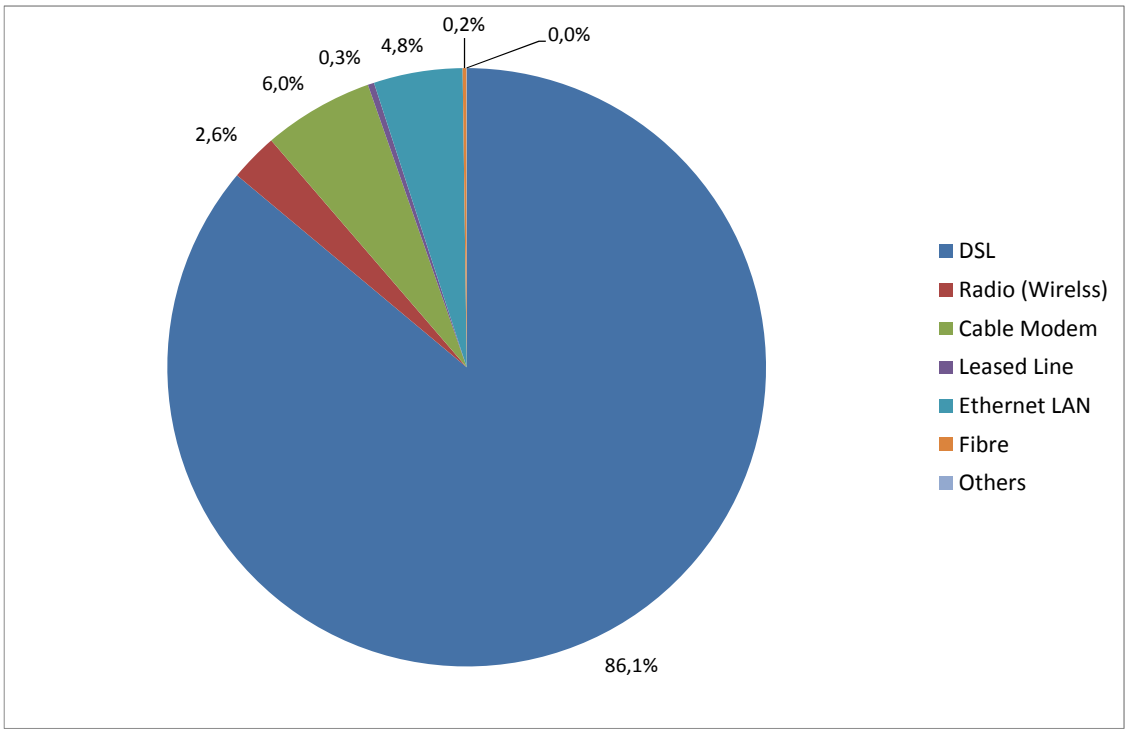
Rather little attention has been paid to date to this potentially extremely valuable asset. Our preliminary impression is that factors contributing to this relative neglect include:

- The rather primitive condition of cable infrastructure in India, very little of which has been upgraded to support digital transmission and broadband data transmission.
- Fragmentation of the cable industry into an estimated 60,000 cable operators.[9]
- The small scale of the smaller cable operators, with the consequence that many cable operators lack the scale, the technical competence, and the business and entrepreneurial skills to successfully deploy broadband data services.

The net effect is that cable accounts for just 6.0% of Indian broadband, compared to more than 86% for DSL as of March 2011, as shown in the following figure.

[6] Cf. Feijoo et al. (2011); WIK (2008).
[7] See for instance the TRAI press release, "TRAI introduces Quality of Service (QoS) Regulations for Cable TV service in non-CAS areas", 2009.
[8] Source: Media Partners Asia Ltd (MPA), http://www.media-partners-asia.com/, 2009. The percentage of cable pay TV subscriptions is expected to decline in the coming years, but the infrastructure remains.
[9] In non-CAS areas. See TRAI press release, "TRAI introduces Quality of Service (QoS) Regulations for Cable TV service in non-CAS areas", 2009.

Figure 1. Current distribution of broadband physical access media.



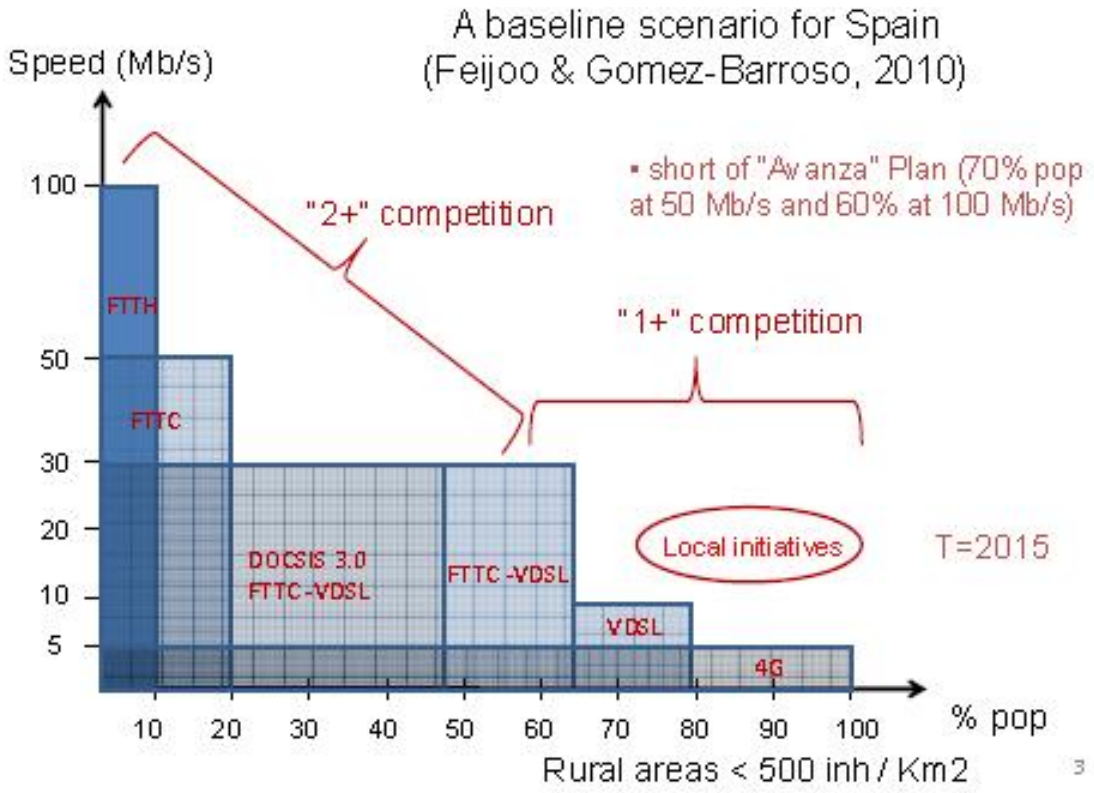
Source: *Indian Service Providers of India (ISPA)*[10]

Deployment of a mix of technologies has the benefit also of enabling infrastructure competition. This is limited in the case of India by the limited deployment of the fixed network and also of the cable network, but public policy should foster as much competition as is realistically feasible. A recent analysis of potential NGA deployment in Spain[11] distinguishes between areas of "2+ competition", where the fixed network, cable and mobile compete, versus "1+ competition", where only fixed and mobile compete. Facilities-based competition, even if limited to narrow geographic areas, may have to tendency to constrain prices to reasonable levels across much larger geographic areas.

[10] At *http://www.ispai.in/Stat3-InternetsubsTechnologywWise.php*

[11] Claudio Feijoo, José-Luis Gómez-Barroso, Sergio Ramos, and Rafael Coomonte,, The Mobile Communications Role in Next Generation Networks: The Case of Spain, presented at ITS 2011, Budapest.

Figure 2. Cost-effective ultra-fast broadband coverage of Spain with a mix of technologies.



Source: Feijoo and Gomez-Barroso (2010)

2 Current plans for broadband deployment in India

The benefits of broadband are widely acknowledged, and the Indian government, to its credit, has identified a number of public policy initiatives that potentially accelerate broadband deployment and adoption in India. Particularly noteworthy are:

- the wide range of broadband initiatives sketched out in the National Broadband Plan[12] of December 2010;
- an initiative to provide inter-city optical fibre throughout India, described in the same document; and
- an initiative to require all cable network operators to upgrade their systems over the next few years so as to make them broadband-capable, described primarily in the TRAI's "Implementation of Digital Addressable Cable TV Systems in India" of August 2010.[13]

If these initiatives were fully implemented, they might potentially impart substantial impetus to broadband deployment and take-up in India. Key research questions for this paper are (1) the degree to which these initiatives could stimulate broadband, collectively or individually, if successfully introduced; (2) whether additional measures should be considered; and (3) the prospects that the initiatives will be successfully implemented in the first place.

In this section, we lay essential groundwork by summarising these three proposed initiatives (Section 2.1) and their respective prospects for successful implementation (Section 2.2).

2.1 Current plans by the TRAI and the Ministry of Information Broadcasting

In this section, we summarise (1) the TRAI's overall broadband objectives (Section 2.1.1), (2) the TRAI's proposal to roll out inter-city carrier neutral fibre optic capacity between cities (Section 2.1.2), and (3) the mandate to upgrade cable systems to digital addressable cable (Section 2.1.3).

2.1.1 General broadband initiatives

The TRAI's general approach is to use a mix of technologies, bearing in mind Indian realities of demographics, economics geography, and path dependencies (i.e. the degree to which future evolution is dependent on the historic path of market development).

The TRAI has observed, rightly in our view, that the potential deployment of broadband by means of DSL is limited unless there were to be a quite substantial increase in the number of

[12] TRAI (2010), "Recommendations on National Broadband Plan", 8 December 2010.

[13] TRAI (2010), "Implementation of Digital Addressable Cable TV Systems in India", 5 August 2010.

fixed lines (which is not seriously in prospect, so far as we can see. As the TRAI notes in the National Broadband Plan, the availability of copper loops in the country is estimated to be about 40 million, but according to conservative estimates, only about 50% of those copper loops are fit to support DSL connections.[14] As of September 2010, 8.9 million broadband connections have been provided using DSL technology, representing 86% of broadband connections. An additional 6% of broadband subscribers are served by means of Ethernet/LAN connections over the fixed network. Thus, nearly half of the fixed lines that are capable of supporting broadband without substantial work are already in use.

The TRAI hopes or expects that the number of fixed network broadband subscribers will increase to 16.6 million subscribers by the end of 2012, and to 22.2 million subscribers by the end of 2014. If one assumes, as seems likely, that few new fixed lines will be installed, and that few existing lines will be upgraded to enable DSL, this means that nearly all DSL-capable fixed lines will already be in service by the end of 2014. Without significant new investment, this would appear to be the end of the line for broadband based on the fixed network in India.

The TRAI goes on to note the importance of cable to Indian broadband deployment. They identify some 80 million cable customers, 70% of whom are claimed by the industry to live in cities of one million or more inhabitants.

This figure itself hints at a significant challenge. Various sources identify the number of cable customers in India as somewhere between 80 and 140 million.[15] The uncertainty in the estimated number of cable subscribers (sixty million) is thus itself much greater than the total number of fixed lines in India!

This uncertainty is primarily the result of a lack of addressability for cable systems. In four metropolitan areas (all of Chennai in 2003, and parts of Mumbai, Delhi and Kolkata in 2006), the use of Conditional Access Systems is mandatory, in consequence of which pay channels are relayed through CAS-enabled or addressable systems. Elsewhere in the country, most cable systems are analogue. Where digitalisation has been voluntarily implemented (a growing trend among the larger Multi-System Operators (MSOs)), it has usually been without addressability. As noted in "implementation of Digital Addressable Cable", "…there is very limited visibility on the subscriber base consuming and paying for the … pay channels … In the absence of addressability, the subscription revenue transaction is being undertaken either as a fixed fee (lump sum), or on the basis of a "negotiated" subscriber base." This lack of visibility is a problem for the industry itself, even more than for policymakers.

[14] See Section 5.18 of the National Broadband Plan. "Functioning of DSL is highly sensitive to the quality of the copper loops. A large number of old pairs may need conditioning to qualify for use with DSL technology. Testing and conditioning each pair is a time consuming and expensive process. Currently, not much investment is being made in the copper network resulting in limited expansion and declining availability with time."

[15] There can be substantial differences even within the TRAI's own estimates, and occasionally even within the same TRAI document. The National Broadband Plan identifies 80 million subscribers as of December 2010 ("India has approximately 80 million cable homes, which are expected to grow to 103 million by 2014."), while the Digital Addressable Cable document identifies 91 million subscribers as of the end of 2009. Given that the average annual growth rate has been on the order of 40%, the Digital Addressable Cable estimate is far greater than the National Broadband Plan estimate. But the National Broadband Plan also identifies 85 million cable subscribers (Section 5.30).

This lack of visibility into the size of the subscriber base is further compounded by the fragmentation of the industry into an estimated 60,000 cable operators.

With this as prelude, we note that the Broadband Plan has great hopes for cable, even though it devotes hardly any page count to cable. Due to the combined initiatives (1) to mandate implementation of digital, addressable cable, and (2) to ensure that all cities are reached with long haul fibre-optic that could serve as a back-haul for broadband offerings, the National Broadband Plan assumes that "[a]ll cable with digital addressability if upgraded to optical fibre will be capable of supporting broadband given that fibre backhaul for providing broadband service is ensured. Even with the modest assumption of just 50% and 70% of cable with digital addressable systems providing broadband, the number of broadband connections provided by cable network by the end of 2012 and 2014 will be 28 Million and 72 million respectively." If 50% and 70% are meant to represent the fraction of homes passed where cable broadband service will be adopted, these estimates do not seem to be "modest" based on international comparison; however, given the appetite for Internet services in India, and the dearth of competition from the fixed network, they might well be achievable in due time.

The TRAI's broadband plans also place great reliance on wireless options.[16] This inevitably raises two questions, both of which are relevant to developed and developing countries but have perhaps a special relevance in the case of India:

- To what extent is mobile broadband an economic complement to fixed broadband and to what extent an economic substitute?

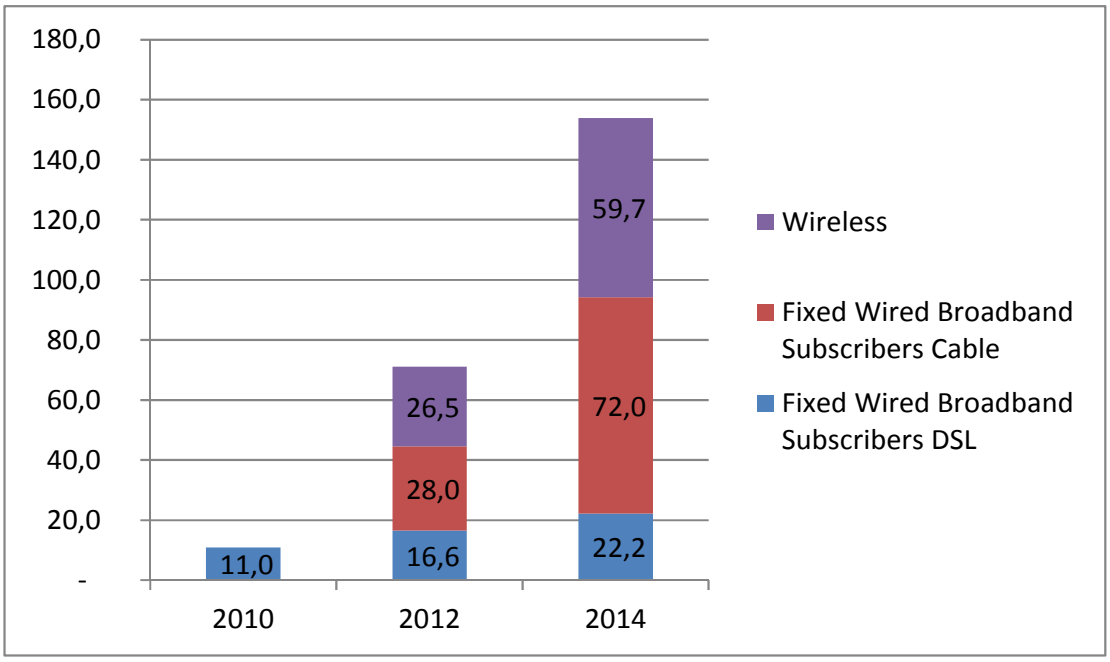
- Spectrum in India is alleged to already be substantially congested (even in the present environment, which consists primarily of voice) due to six major national MNOs competing for limited spectrum. How will extensive new mobile data be accommodated within existing spectrum allocations and assignments? Could new technologies such as LTE save enough bandwidth to matter?

In areas that are reached neither by cable nor by the fixed network, wireless is surely the right answer for India. Wireless solutions are also surely to be preferred for areas of lower population density, where unit costs for fixed solutions are higher and where spectrum contention is less problematic. Nonetheless, these questions bear critically on the degree to which wireless broadband solutions will ultimately prove to be satisfactory.

All told, this leaves us with the following expected evolution of broadband in India.

[16] See Section 4.6: "The growth projections of mobile subscribers is likely to be maintained and expected to reach 888 million mobile subscribers by 2012 and one billion mobile subscribers by 2014. Considering that the percentage of the data subscribers is at least maintained, if not increased further, the number of data subscribers through mobile device will be 353 million and 398 million by the year 2012 and 2014 respectively. With a conservative estimate, it is expected that atleast 7.5 % of data subscribers capable of using Internet (i.e 26.5 million subscribers) will adopt broadband by 2012 and about 15% (i.e 59.7 million subscribers) by 2014."

Figure 3. TRAI's projected evolution of broadband in India.



Source: Marcus/Jain, based on the TRAI National Broadband Plan (2010)

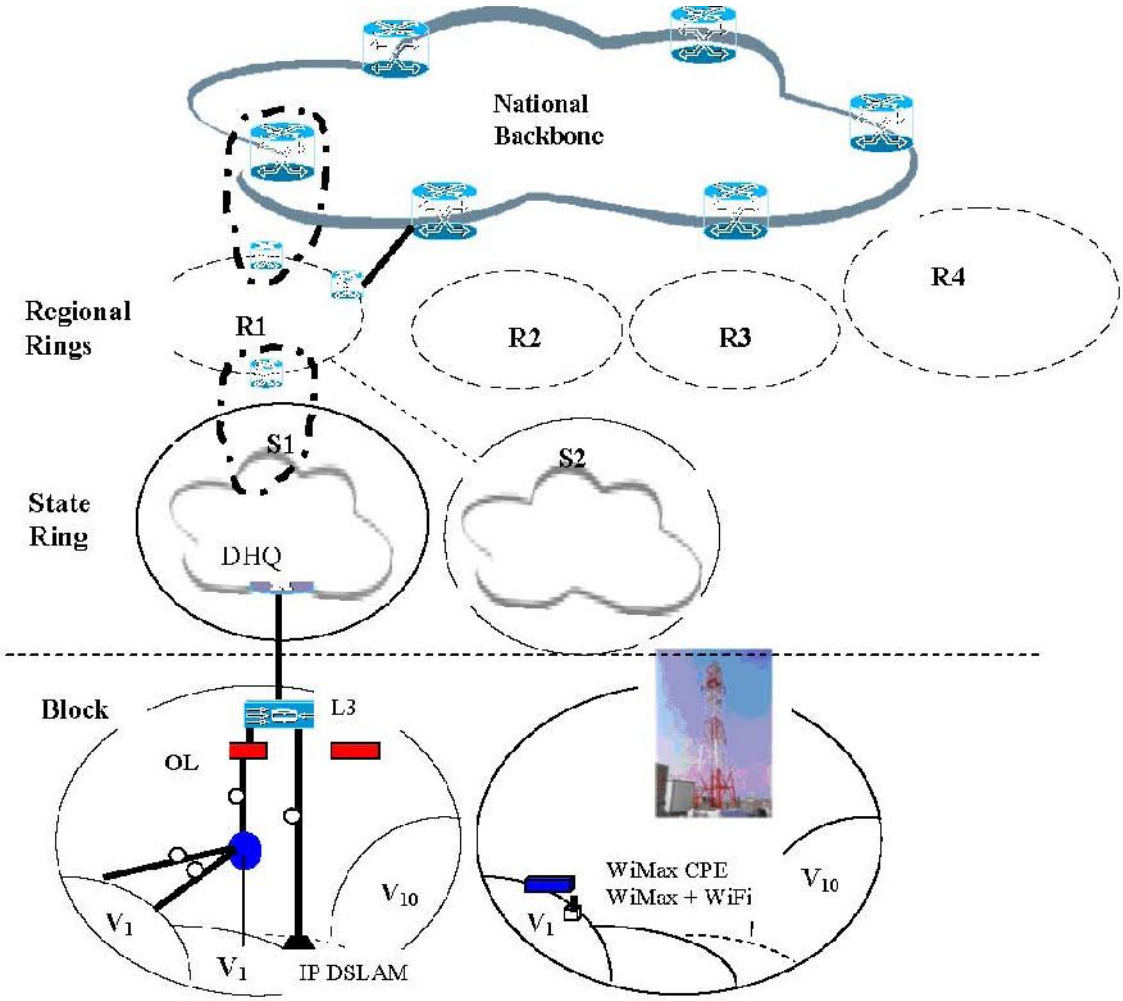
2.1.2 Inter-city optical fibre throughout India

The TRAI has noted the need to facilitate broadband deployment by ensuring sufficient fibre-optic based back-haul capacity at national, regional and DHQ level. This potentially serves multiple purposes. It potentially (1) accelerates broadband deployment; (2) eases upgrade of mobile networks to support high speed data carriage, e.g. by LTE; and (3) promotes additional competition at regional and local level.

The TRAI reasons as follows: "The aggregation network for broadband service has been deployed by large service providers to meet their own requirements. Standalone service providers who offer their own broadband service would have to connect their equipment to a large service provider's aggregation network or directly to the backbone network. In the latter case, the small service provider would have to build its own aggregation network at a substantial cost. Most pan-India service providers have built their own backbone network; others would have to interconnect their network to one or more of these backbones to offer interstate VPN or broadband service to the customers. Non-availability of aggregation access network, especially in the rural areas, and the backhaul from Blocks to the DHQs at competitive rates to the service providers is one of the major impediments in the growth of broadband."

The TRAI proposes the creation of a national network (with state participation) with connections to multiple service providers at, for example, the DHQ level. The estimated cost (65,669 crore) is significant, but does not appear to be disproportionate relative to the capabilities of the proposed backbone network.

Figure 4. Architecture of TRAI's proposed fibre-optic backhaul network.



Source: TRAI, National Broadband Plan (2010)

2.1.3 Upgrade of cable systems to digital addressable cable

The TRAI has proposed an entire constellation of initiatives to drive migration of the Indian cable industry from analogue facilities (or in some cases non-addressable digital) to digital addressable cable.[17] It is likely that the primary benefits to the industry would be in terms of more rational and more profitable video services, but a not inconsiderable benefit would also flow from the ability to offer highly capable broadband to a large fraction of Indian households.

[17] See TRAI (2010), "Implementation of Digital Addressable Cable TV Systems in India", 5 August 2010. The main proposed actions are summarised in Chapter 5 of the National Broadband Plan.

The measures proposed by the TRAI include both outright mandates and positive incentives – "both carrot and stick". As the TRAI notes:[18]

> The digitisation of the cable TV network would involve upgradation (sic) of the distribution network and cable headends. In addition, there is requirement of encryption (CAS), subscriber management system (SMS), Set Top Box at the subscriber premises and skill development. The total requirements of fund estimated by different sections of the industry vary from Rs. 30,000 to Rs. 60,000 crores. Even though there is a wide variation in the industry estimates of overall investment required for achieving digitization with addressability, there is no disputing the fact that the requirement of funds is very large. Therefore the Authority, in its recommendations, has proposed a number of possible incentives that can be offered to various stakeholders so that digitization with addressability is implemented in the shortest possible time and the transition made is sustained. These include income tax holiday …, reduction of the basic custom duty on the major items in digital addressable broadcast distribution i.e. digital headend equipments and STBs, to zero level for the next 3 years and rationalization of the taxes and levies on the distribution sector. Also the MSOs/LCOs should be eligible to seek Right of Way (RoW) on non exclusive basis for laying optical fiber being a vital infrastructure.

After an extensive consultation, the Ministry announced that it intends to move forward as the TRAI proposes, with however a slightly relaxed schedule.[19] Rather than a sunset for analogue cable of the end of 2013, it will be the end of 2014.

In parallel with these changes, the TRAI has proposed to eliminate current licensing restrictions that presently inhibit small cable operators from offering broadband services. They advocate the reintroduction "of Category C license for the ISPs with a Districtwide jurisdiction. This would enable small operators including the cable operators to offer Internet service along with other services. Since the intention is to enable small operators to acquire ISP licence, the Authority has proposed that those operators, who have a turnover of less than Rs.1crore, need not be charged any licence fee. If, MSOs, and more importantly LCOs in the rural areas, are provided access to nearest concentration/aggregation point of the national broadband network at par with ISP, the business model of the cable networks would become attractive enabling thereby to achieve the twin objectives of the spread of addressable digital cable TV services and the broadband services to every nook and corner of the country."[20]

[18] National Broadband Plan, Section 5.35.

[19] See "Final Views of Ministry of Information Broadcasting on Timeline for Implementation Digital Addressable Cable Systems in India". This proposed time schedule is still subject to approval of the Cabinet.

[20] National Broadband Plan, Section 5.39.

2.2 Prospects for success

It is all well and good to plan, but ultimately success must be measured by the degree to which the plans and their respective aims are achieved. As the TRAI has itself observed, the broadband targets of 2004 have been missed by quite a wide margin,[21] and the degree to which public policy initiatives contributed to even that achievement is not clear (at least, not to the authors of this paper).

In this section, we provide our considered view of the degree to which the three initiatives described in the Section 2.1 are likely to be successfully implemented.

- The National Broadband Plan[22] of December 2010:
- An initiative to provide inter-city optical fibre throughout India, described in the same document;
- An initiative to require all cable network operators to upgrade their systems over the next few years so as to make them broadband-capable, described primarily in the TRAI's "Implementation of Digital Addressable Cable TV Systems in India" of August 2010;[23] and
- Provision of adequate spectrum for fixed and mobile wireless broadband.

These appear in Sections 2.2.1 through 2.2.4, respectively.

2.2.1 General broadband initiatives

Although a lot of regulatory effort has gone into developing a "National Broadband Plan", significant components of which focused on wireline connectivity and digitization of cable, it failed to adequately address the issue of fast deployment of broadband, especially in rural and semi-urban areas.

Successful deployment implementation will clearly depend on a mix of DSL, cable, mobile, and the backhaul network. We see exposures in all four areas.

For DSL, we have already noted the limited deployment of the fixed telephony network, and limited prospects for its expansion. This low penetration of the fixed network, together with various impediments related to cable (including the fact that TV penetration at only 38% in rural areas, plus the low propensity of rural cable operators to upgrade and of subscribers to pay additional costs for *Set Top Boxes (STBs)*, together with the higher costs of pay TV, all of

[21] National Broadband Plan (2010), Section 4.1, "Broadband policy announced by the Government in December 2004 set a target of 9 million broadband connections by the end of the year 2007 and 20 million connections by the end of the year 2010. The achievement has just been 10.30 million broadband connections by the end of September 2010."
[22] TRAI (2010), "Recommendations on National Broadband Plan", 8 December 2010.
[23] TRAI (2010), "Implementation of Digital Addressable Cable TV Systems in India", 5 August 2010.

which we discuss in Section 2.2.3) imply that, despite the "India growth story", broadband growth through wireline is likely to be delayed.

Spectrum receives rather little attention in the National Broadband Plan, but we perceive significant risk that efforts to use fixed or mobile broadband to fill gaps in wireline broadband coverage are likely to be impeded by lack of radio spectrum.

Finally, our perception is that the proposed national fibre-optic back-haul network is already delayed and is likely to experience further delay (see Section 2.2.2).

2.2.2 Inter-city optical fibre throughout India

On the face of it, the proposed national network would seem to be a sensible innovation, and there is substantial positive international experience with comparable initiatives.

Consider, for example, the case of South Korea, which was the first prominent front-runner in broadband deployment and adoption. Many have assumed, mistakenly so far as we can determine, that the South Korean ADSL deployments benefited from substantial direct subsidies. There were subsidies, but not to the last mile. Instead, the South Korean government (1) provided highly subsidised personal computers to the general population, thus stimulating *demand* for broadband rather than *supply*, and (2) the South Korean government funded a fibre optic backbone inter-connecting all significant cities in South Korea.

TRAI has specified that deployment of fibre be done through a *National Optical Fibre Agency (NOFA)* – a wholly government owned holding company whose role would be to oversee the overall architecture, planning, procurement, deployment and maintenance of the shared fibre infrastructure. It would also raise both debt and other finances for its operations. Nationwide deployment is envisaged through state level *State Fibre Optic Agencies (SOFA)* in which NOFA will have 51% equity with the remaining 49% being held by state governments. The role of SOFA would be to implement the overall architecture as conceived by NOFA, and to implement and maintain the backhaul and village level aggregation to the block level. This is envisaged as a shared infrastructure to be made available to any service provider, on a commercial basis, thus generating revenues. The states would be responsible for handling the ROW issues. The rates at which leasing of infrastructure by NOFA and SOFAs and users would be determined by the TRAI.

As per the TRAI plan, by December 31, 2011, all stages up to the planning and procurement of material by NOFA were to be completed (Table 1). As of early January 2012, NOFA or SOFA had not even been formed. This plan is obviously delayed.

Table 1. TRAI's proposed list of implementation actions.

Sr No	Activity	Completion Date
1	Decision of the Government	31st January, 2011
2	Creation of NOFA	28th February, 2011
3	Addressing letter to States	15th March, 2011
4	Creation of all SOFAs	31st March, 2011
5	Network Planning by SOFA/NOFA	30th June, 2011
6	Finalization of executing agencies	30th September, 2011
7	Completion of trenching and laying fiber for backhaul and access traffic aggregation	30th June 2012
8	Planning and material procurement by NOFA	31st December 2011
9	Installation, testing and commissioning of equipment for backhaul from all blocks and aggregation of all Panchayat villages by SOFA	30th June 2011 to 30th, 31st August 2012
10	Planning and material procurement for urban areas by NOFA	31st December 2011
11	Laying of cables, equipment installation and commissioning in phased manner in urban areas	31st December 2012

(Source: *TRAI, Recommendations on National Broadband Plan, December 8, 2010)*

While it is a good plan to have a ubiquitous fibre infrastructure, there are significant issues in implementing this plan at the national level as conceptualized by TRAI. TRAI's recommendations on NOFA and SOFA are supply-driven rather than demand-driven. They do not provide a framework for exploiting the existing institutions, linkages, or infrastructure for broadband deployment.

To exploit the backhaul capabilities of existing fibre optic cables owned by various agencies, especially BSNL (the state owned incumbent) and other private and public agencies, TRAI could have just developed the regulatory frameworks by which existing infrastructure, both public and private, could be made available to a variety of agencies. In case this framework led to lower charges than what is commercially viable, then the funding for the viability gap could have been made from the USOF or other sources.

Although many countries have taken the development of a national optical backbone as a public investment, its implementation could be done through a variety of means that involve the private sector. For example, Build Operate Transfer (BOT) models in highway development have worked well in the road sector in India. In this case, the private sector collects regulated tolls to offset its costs. The private incentives of profit ensure minimum time for construction. In contrast, in considering TRAI's suggestion, it is difficult to envisage how a highly centralized and hierarchical agency would be able to take into account the demand drivers of customers in order to function effectively.

We suggest that for greenfield deployment of fibre optic, it is necessary for TRAI and DOT to work with other infrastructure sector agencies in the country when coming up with such national infrastructure plans and identify how private sector could get involved. For example, since there is a dearth of national and state highways and rural roads, several new highways

and rural roads are getting constructed or upgraded. The potential cable laying organization could use this opportunity for laying cable. Incentives for both parties to cooperate could be for example in the form of lower tax rates.

2.2.3 Upgrade of cable systems to digital addressable cable

The Bill to amend the Cable Television Networks (Regulation) Act 1995 for implementing total digitalization of Cable TV networks in the country in four phases was passed by the Parliament on December 19, 2011. The process of digitalization has to be completed by December 31, 2014. The affordability of the set top box for subscriber, the costs of last mile upgrades for the LCO and TRAI mandated tariffs for pay channels are going to be the major determinants of progress.

Even if adequate progress is made, the impact of this initiative on broadband deployment is going to be limited. In the rural areas, TV ownership is 38% as compared to nearly 80% in urban areas.[24] It is estimated that homes with cable and satellite channels are 60 million and 56 million in urban and rural areas respectively, with 9 million and 17 million digital as of 2011.[25] This is through both digital cable and Direct to Home (D2H) satellite television. The rate of growth of the cable and satellite ownership is, however, quite considerable.

Digitization, an essential prerequisite to using broadband, is increasing.[26] DTH has reached a penetration of 26% of the pay subscriber base, whereas analogue cable and digital cable comprise nearly 66% and 5% respectively.[27] The extent of digitalization is 34% and 12% respectively in rural and urban areas respectively. A high percentage of digitalization in rural areas is due to DTH. It is estimated that rural areas and small towns account for 76% of DTH subscribers.[28] With value added services such as VOD, PVR etc, and the relatively better off population in rural areas prefer the DTH option.

On the other hand, with the current state of technology in India, DTH subscribers cannot use a great deal of interactivity, limiting the possibility of DTH as a broadband channel. Further, challenges specific to the DTH segment in India are the lack of transponder capacity (said to be eased by Indian Space Research Organisation now), issues of reception in coastal areas etc. A self owned dish allows continuous watching (through personal generator sets) in the face of a power cut, giving an edge to DTH over cable TV, as power cut at the LCO end could stop the transmission. In addition, DTH is likely to gain impetus as there are large rural areas, especially those in hilly and remote regions, where provision of DTH is easier.

The targets of cable broadband penetration put forward by the TRAI in Section 2.1.1 of the National Broadband Plan, "28 million and 72 million", are gross over-estimates. They are contingent on digitization and addressability of cable networks. TRAI has estimated that this

[24] "Television Audience Measurement (TAM) Media Research Annual Universe Update – 2011", available at http://www.tamindia.com/tamindia/Images/Overview_Universe_update_2011.pdf.
[25] Ibid.
[26] KPMG, "India Media Industry", page 15.
[27] KPMG, "India Media Industry", page 15.
[28] http://www.boxofficeindia.co.in/....devendra%20parulerkar, 3 Dec 2011.

would require between Rs 30-60,000 crores to "upgrade the distribution network and cable headends involving encryption, Subscriber management systems and skill development".[29] These amounts would have to be borne by the MSO, the LCOs and subscribers (STB). The amounts cited above are aggregate. The success of digitization and addressability will depend on the costs of implementation vis-à-vis the additional revenue consequent to the change. In metros and larger cities, the MSOs and LCOs could possibly recover their investments, both due to lower unit costs of implementation as a consequence of higher population densities, as well as higher ability to pay of urban customers. The relevance of the Internet based content for urban customers may be higher, and thus could lead to higher willingness to pay. However, in poor urban areas and several rural areas, the ability to pay even for analogue cable TV is poor. Several rural cable TV operators charge Rs 50 –Rs 75 per month and give a bouquet of FTA. Pay TV subscription is limited. Such operators and subscribers would not have the financial wherewithal to upgrade the last mile necessary for digitization. Timely availability of STBs for digitization is an issue both in urban and rural areas due to the requirements of importing as there is little or no indigenous production.[30]

Further, broadband deployment envisages a cable modem and end-user device, the costs of which are going to be major deterrents for adoption of broadband.

The availability of broadband in metros and cities is not a major issue as there are several alternatives such as DSL, cable broadband etc. The lower broadband penetration in urban areas is due to lower adoption rather than lack of supply. As per TRAI Consultation paper on National Broadband Plan (page 3), 21.45% of the wireline connections have DSL broadband activated. This small fraction could be due to either inability of BSNL/MTNL to activate DSL or lack of demand from the customer side (given the relatively higher prices of PCs). Given this low demand in urban areas, we do not expect that a cable television operator in a rural area to be able to make a business case for broadband through upgrade to digitization. For the demand side to pick up, a whole set of other issues such as the felt need for Internet, relevance of content, local language content will need to be addressed. Further, the cost of set-top box, even if brought down due the greater push for digitization, is a substantial deterrent for its rapid growth.

For rural areas, digitized cable does not seem an appropriate mechanism to provide broadband for reasons cited earlier. In urban areas, the issue of broadband penetration seems one of demand, rather than supply. Further, given the delays in a publicly available backbone, the issue of broadband connectivity through a digitized cable network remains limited, possibly to urban areas.

Meanwhile, we have our doubts about the speed with which consumers will be willing to acquire and install Set Top Boxes (STBs). The TRAI/Ministry plan depends on every consumer acquiring an STB. This is unlikely to complete as planned by the end of 2014. This is not an issue for the four metros where CAS is already required, but it is likely to be an issue everywhere else.

[29] National Broadband Plan.

[30] Hathway Annual Report available at http://www.hathway.com/corporate/pdfs/annual-2010-11.pdf

Finally, we note that the government's plan depends on both carrot and stick. Relative to the cable operators, the threat to withdraw the cable licence is the stick; however, the ability to withdraw the licence is likely to be weak, given the dispersed nature of operations of cable operators in semi-urban and rural areas. Many of the cable operators may not even be registered in the first place. The number of registered cable operators is 48,000. Given that there are only few large operators, and that they have multi-city operations, it is clear that a very large number of cable network operators must be small operators limited to small geographic regions within cities or semi-urban areas.

2.2.4 Spectrum as an enabler for fixed and mobile wireless broadband

For spectrum, the plan acknowledges that more than 600 MHz is needed in metros, and more than 300 MHz in big cities. This is not available today, and nothing in the National Broadband Plan is likely to free up significant spectrum in the 2011-2013 time frame.

While both the twelfth five year plan and the draft of the National Telecom Policy 2011 (which is yet to be formally announced) do focus on Spectrum as a critical resource, and on the appropriate instruments and institutions required to manage it strategically, it will be quite some time before any of the recommendations get implemented.

The aspect of broadband that does not require significant institutional changes, has significant private incentives and already has a wide potential user base is through mobiles. Many argue that with the current state of technology, wireless broadband speeds do not compare with wireline speeds, and the appropriate mode of infrastructure deployment for broadband should therefore be wireline. While this is true, given the likely gaps in wireline broadband deployment noted previously due to limited availability of fixed line and cable, broadband through mobiles seems like the most pragmatic solution for low density and/or remote areas in the immediate term and the near future.

There are many reasons why it is important to make more spectrums available for mobile services. Spectrum serves as an enabler for low-bandwidth alternative services (including SMS-based services) that substitute for broadband, possibly mitigating the impact of gaps in broadband coverage.

While it would be ideal to have high bandwidth, rich media applications for all citizens of the country, even on a mobile, the practical reality is that a large number of citizen transactions and information needs can be realized through SMS based systems that interface with the Internet, if designed properly. Such systems could be advertisement based and hence would not be expensive for the user. Since these could be interactive voice response based, they do not require a literate population, a constraint in India. Further, the wide coverage of cellular networks, as cited earlier, would make a large number of services available to the citizens within a short time frame. An example of such a system is the ticket reservation system of Indian Railways, which besides being web based is also significantly SMS based. It also has an advertising revenue based model.

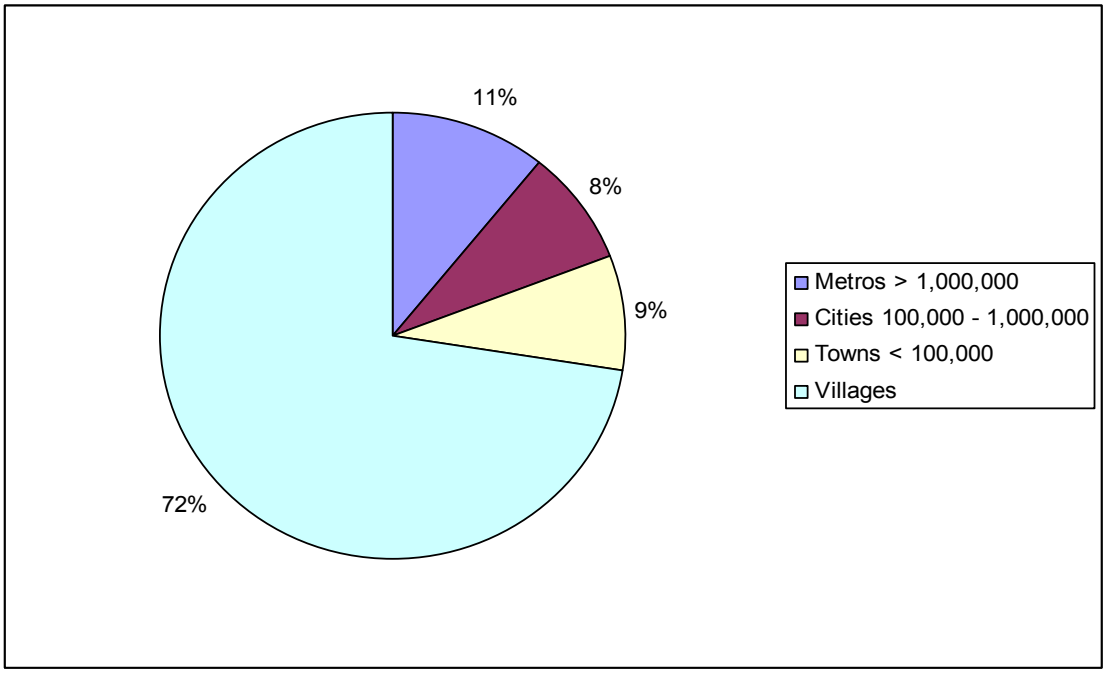
Therefore, the role of the government should be to facilitate further proliferation of cellular networks through making more spectrums available, so that operators are not spectrum constrained and have consequently higher costs of service provision.

3 Economic characteristics of an ideal, technologically neutral deployment

The TRAI's National Broadband Plan rightly notes that India is a vast land with substantial variation in population density, disposable income, existing network build-out, computer literacy, and language. No one-size-fits-all solution is likely to be effective and efficient for the entire country; rather, a mix of technologies tailored to local circumstances will be required.

It is perhaps helpful to briefly review key demographic drivers in India. A large fraction (some 72%) of the 2012 estimated population of 268 million households are to be found in villages; however, a still quite large number of people live in mid-sized cities (up to 100,000 inhabitants), large cities, and major metropolitan areas. It is also worth noting that the number of individuals per household (4.2 urban, 4.7 rural) is much higher than in the United States or Europe.

Figure 5. Fraction of households in metros, cities, towns and villages as of 2012.



Source: *Census of India as reported in TRAI's National Broadband Report (2010)*

To achieve anything approaching full coverage, it is necessary to get beyond the cities; however, the 40 million fixed telephony lines are heavily concentrated in larger metropolitan areas. Even for the cable television networks, an estimated 70% (56 million) of the 80 million connections identified by the TRAI are in cities of more than one million populations. The fixed telephony network is not expanding significantly. The cable television has enjoyed rapid growth, estimated at 40% per year, but one can reasonably expect that there are limits to this growth in the near and medium term – first, because the density of subscribers will be below some critical threshold, and second because the back-haul network may not be up to the job of video distribution and data back-haul.

It thus becomes clear that any comprehensive solution will necessarily depend on a mix of fixed telephony network, cable television, and wireless (presumably mobile) services, as the TRAI has assumed. The question then becomes, what mix is optimal? What mixes are realistically achievable in the near to medium term?

3.1.1 Which technologies do best under which conditions?

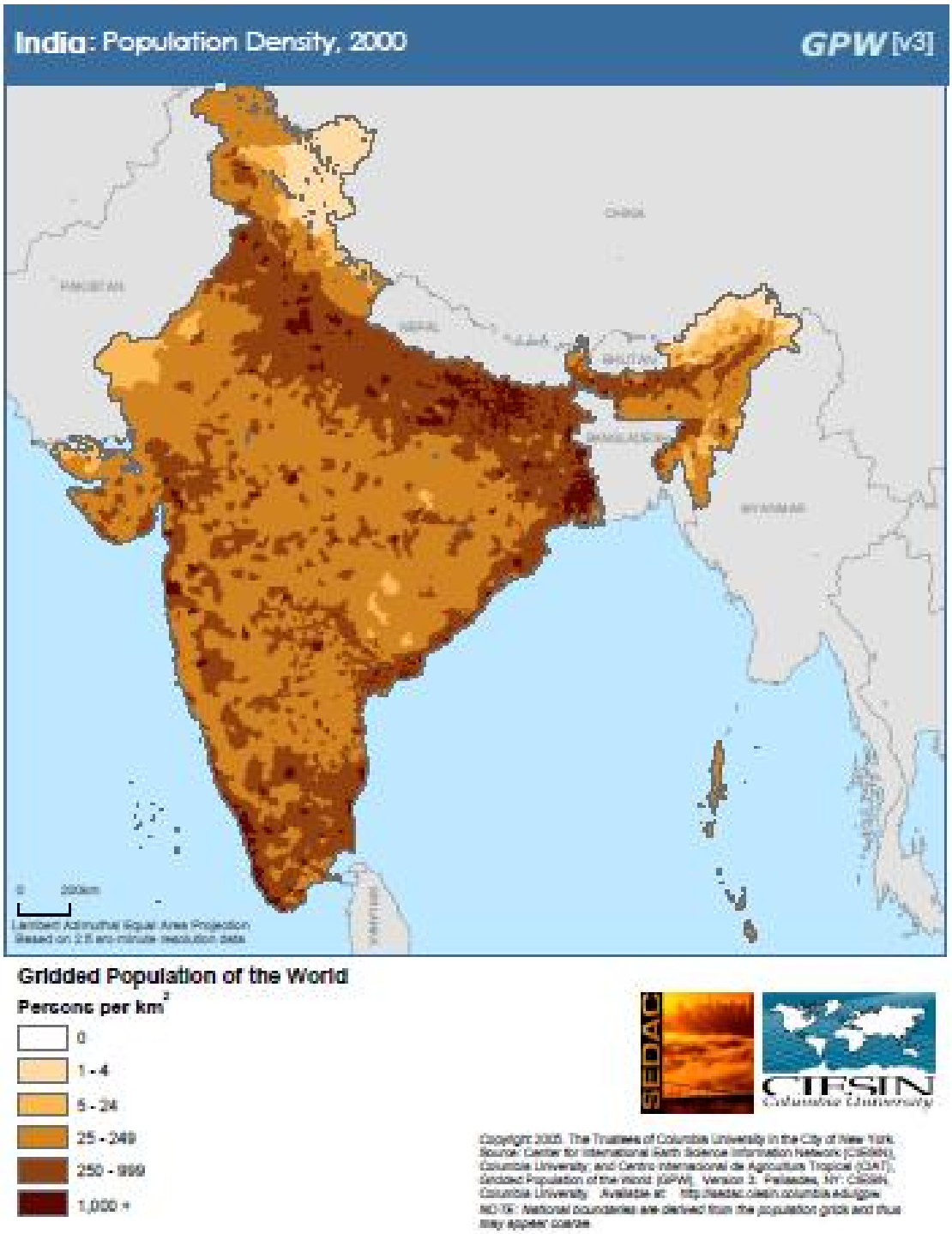
A great many factors influence the optimal choice of technologies. Among the most important are:

- The density of potential subscribers;
- The degree of disposable income;
- The existing footprint and quality of the fixed telephone network;
- The existing footprint and quality of the cable television network; and
- The availability of spectrum suitable for fixed and mobile voice and data services.

India is generally viewed as a densely populated country, but it is also a vast country with substantial regional variation. There are an estimated 368 inhabitants per square kilometre, which is much higher than the global average of 52 inhabitants per square kilometre (of land area excluding Antarctica).[31] Even so, as many as 32 countries are more densely populated than India. As can be seen in Figure 6, a substantial fraction of India's territory is heavily populated; nonetheless, there are many areas that are notably sparse in population.

[31] Wikipedia contributors. "List of sovereign states and dependent territories by population density." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 31 Dec. 2011. Web. 31 Dec. 2011.

Figure 6. Population density of India.



Source: *SEDAC/CIESIN Columbia University, Gridded Population of the World (GPW)*.

As we have seen in Figure 3, the TRAI expects deployment of DSL to reach some 22 million subscriptions, which represents substantially all of the copper lines that could support DSL without significant investment in conditioning. The bulk of the growth – to 106 million

subscriptions in 2012, and to 160 million in 2014 – must come from cable television and from wireless broadband.

Any numbers of studies have considered the question of the proper mix of copper-based broadband, fibre-based broadband, cable television (DOCSIS) broadband, and wireless broadband. In the discussion that follows, we draw primarily on a study by Feijoo and Gomez-Barroso (2010) that considers the appropriate role of mobile (e.g. LTE) relative to cable and fixed telephony in deployment of ultra-fast broadband access in Spain.[32]

A few generalisations naturally flow from general experience and from the Feijoo/Gomez-Barroso analysis:

- Where the copper network exists, and is of suitable quality, it will tend to provide a cost-effective path to broadband.
- Where the cable television network exists, and is of suitable quality, it will tend to provide a cost-effective path to broadband.
- In areas of low density or challenging geography, there may not be a business case to deploy fixed or cable networks.
- Where neither the fixed telephone network nor the cable network exists, many people will wish to adopt wireless broadband solutions as their primary network choice.
- Where fixed and/or cable broadband is available, mobile broadband will be used as an economic *complement* to those services. It may also serve as an economic *substitute* for fixed broadband (for example, by means of a PC dongle).

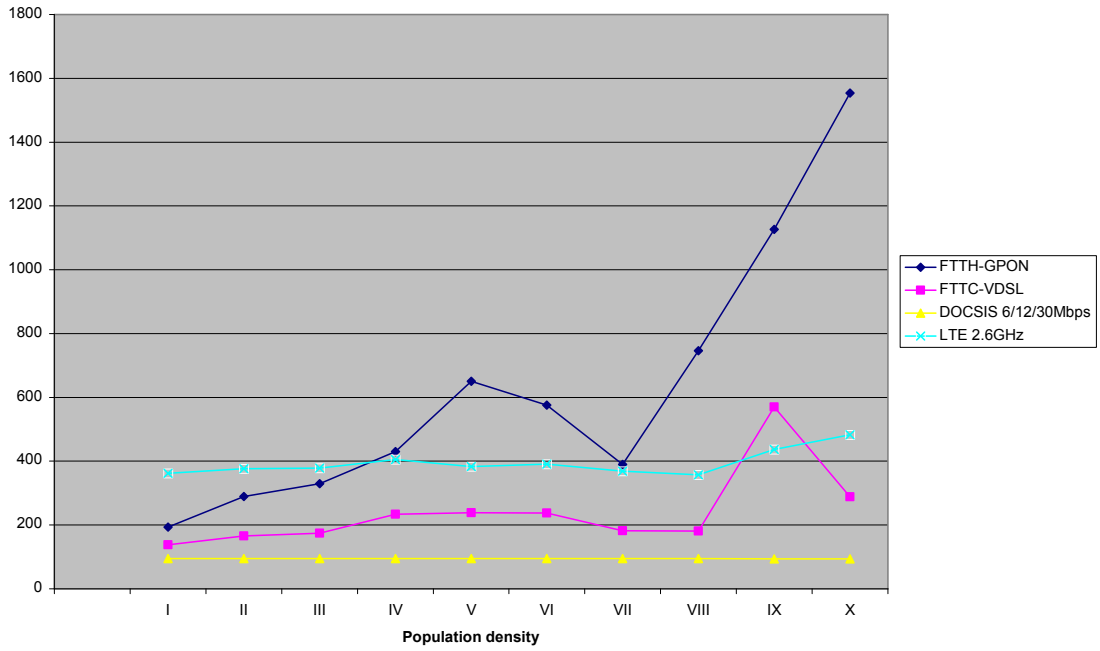
The Feijoo/Gomez-Barroso analysis shows these tendencies clearly. The paper must however be interpreted with some care in the Indian context. That study was concerned was ultra-fast (expecially fibre-based) broadband, not with conventional ADSL. The cable upgrades to DOCSIS 3.0 that were considered started from fairly modern digital cable systems, e.g. DOCSIS 1.0. They were considering a country with a nearly ubiquitous fixed telephone network, substantial cable television, and higher labour costs than those that prevail in India. There are differences, but there are also similarities, and most of the broad conclusions are still relevant.

Their estimates of the cost of achieving ultra-fast Next Generation Access (NGA) distinguish among ten categories of population density, ranging from less than 5 inhabitants per square kilometre to more than 10,000 inhabitants per square kilometre. Considering the cost of basic service by Fibre-to-the-Home (FTTH) / GPON, by Fibre-to-the-Curb / VDSL, by DOCSIS 3.0 cable at speeds of 6, 12 or 30 Mbps, and by wireless (LTE at 2.6 GHZz), they found that LTE was more expensive than fixed solutions where population density exceeded 3,000 inhabitants per square kilometre. Cable solutions were largely independent of density

[32] Claudio Feijoo, José-Luis Gómez-Barroso, Sergio Ramos, and Rafael Coomonte,, The Mobile Communications Role in Next Generation Networks: The Case of Spain, presented at ITS 2011, Budapest.

provided that the cable was already in place. Upgrades to VDSL or the FTTH tended to become much more expensive on a per-subscriber basis as population density declines.

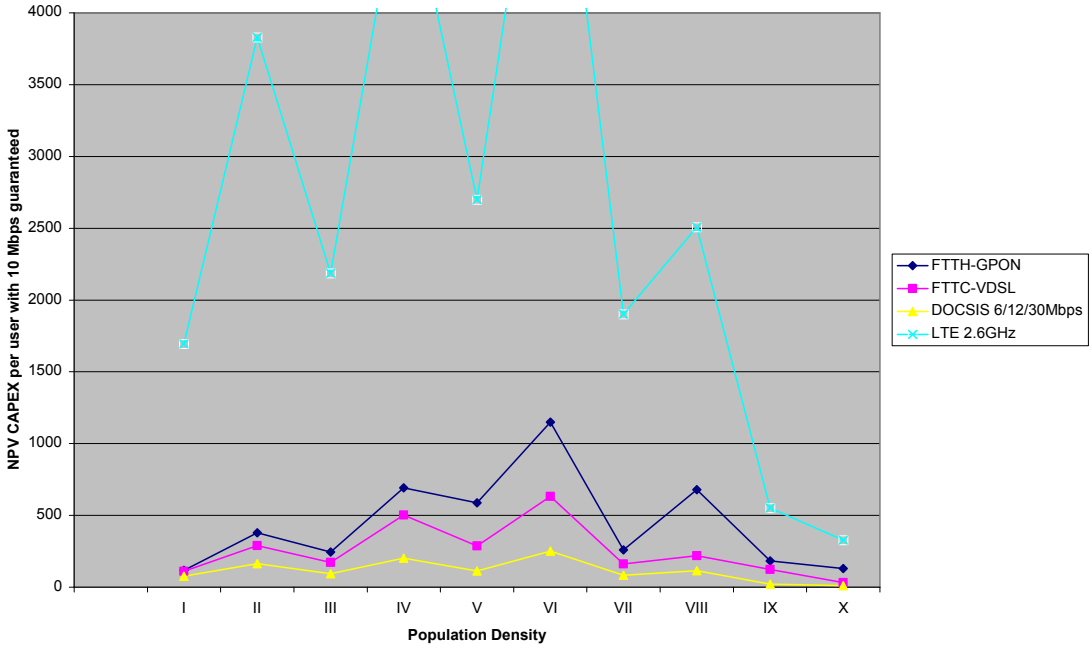
Figure 7. Annualized present value of capex per user (€).



Source: *Feijoo / Gomez-Barroso (2010).*

If, however, one assumes that there is a requirement for guaranteed bandwidth of 10 Mbps – somewhat higher than the 2 Mbps that TRAI has assumed for 2012, possibly increasing to 4 Mbps in urban areas in 2014 – then the fixed solutions are greatly superior to wireless.

Figure 8. Annualized present value of capex per user (€) with a requirement for a guaranteed 10 Mbps.

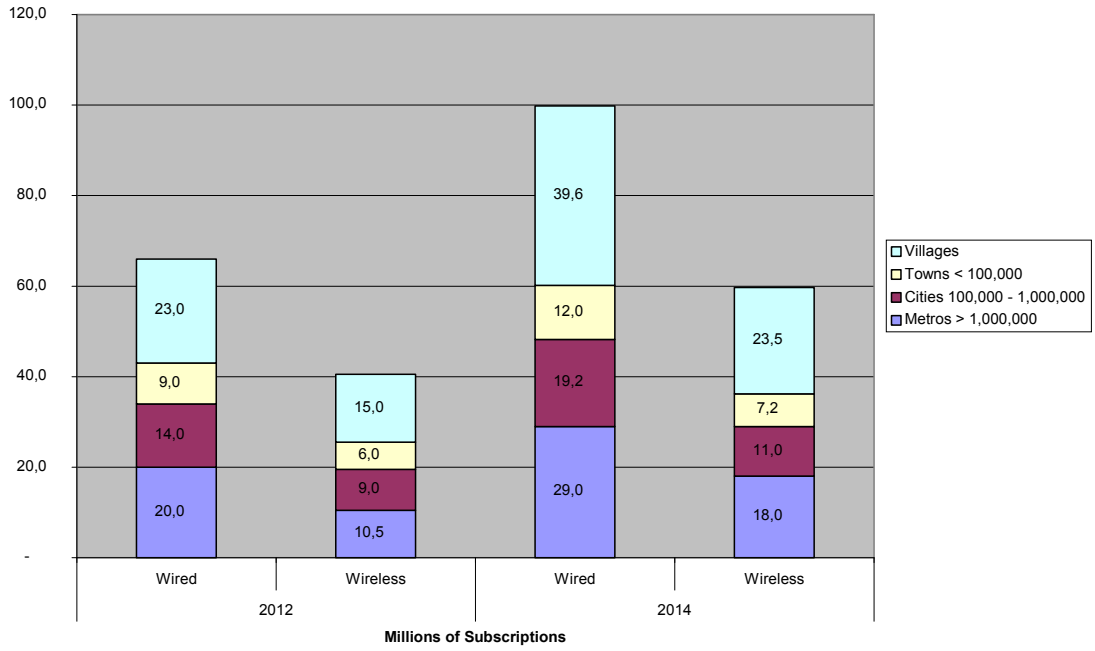


Source: *Feijoo / Gomez-Barroso (2010).*

3.1.2 Which considerations are relevant in India?

The TRAI's plans call for substantial wired and wireless broadband in metros, cities and villages, as shown in Figure 9.

Figure 9. Millions of subscriptions for wired and wireless broadband in metros, cities, towns and villages.



Source: *TRAI, National Broadband Plan (2010)*

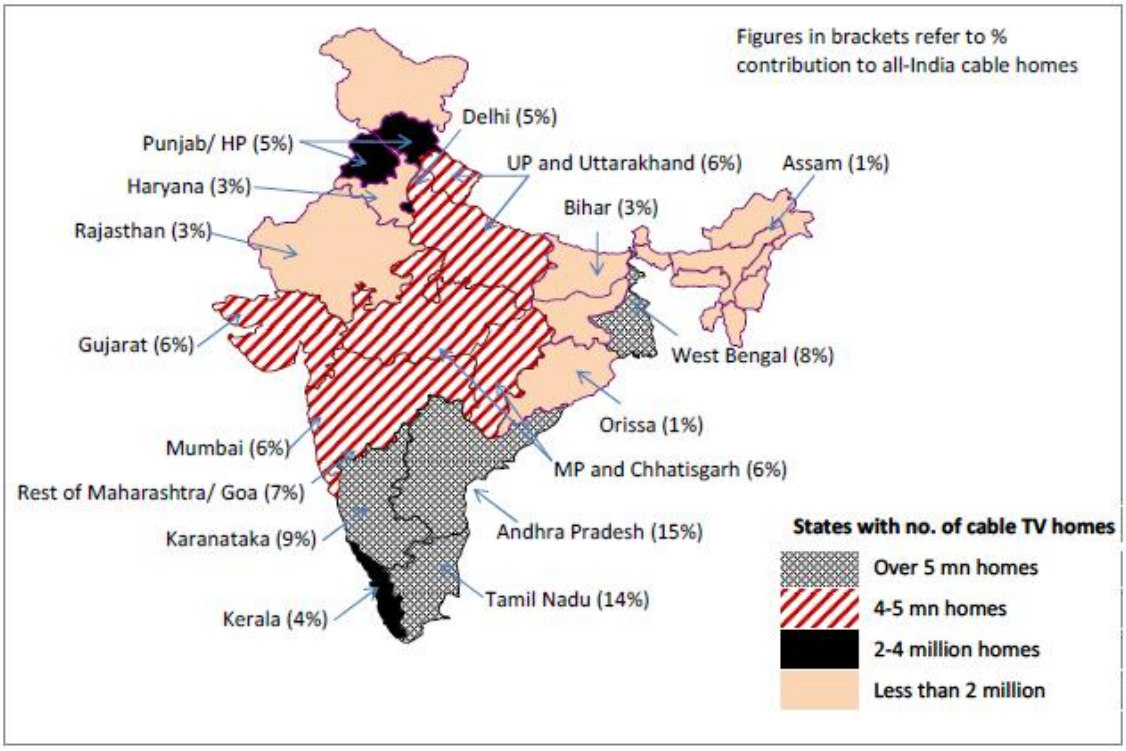
Key questions to consider are:

- What are the maximum limits of the fixed network in India as regards broadband?
- Where is the cable? How much of it could be upgraded to DOCSIS 3.0 at reasonable cost? Are the upgrades likely to take place quickly?
- The mobile network is widely deployed, but spectrum is already scarce. How much spectrum is needed, and where? Will it be available?
- How relevant is it to add fixed and mobile broadband subscriptions? Are they complements, or substitutes? Mobile tends to serve the individual, while fixed serves the household.

For the fixed network, the TRAI's targets of 16 million subscriptions in 2012 and 22 million in 2014 seem to be ambitious but potentially realisable. At that point, no further ADSL will be possible without significant upgrades to the fixed network. We consider it unlikely that a substantial number of new lines, whether copper or fibre, will be deployed in the near to medium term. A question that we do not address, but that may well merit study, is the degree to which the 18 to 20 million low quality copper lines might be upgraded.

The deployment of the cable television is selective, both among states (see Figure 10) and as a function of the size of the town or city in question. As previously noted, some 70% of cable is currently deployed in cities with a population of more than one million.

Figure 10. Distribution of cable subscribers in India.



Source: *TRAI, Implementation of Digital Addressable Cable, 2010*.

As regards upgradability, the cable in the four CAS metros has for the most part already been upgraded. As a general rule, the smaller the town or village, the greater the likelihood that the plant is old, and that the cable is operator has little ability or motivation to upgrade.

Industry sources have estimated a one-time cost of Rs. 30,000 to 60,000 crore to upgrade existing cable plant to digital addressable cable throughout India.[33] This corresponds to € 4.4 to € 8.7 billion at current exchange rates.[34] Given the rapid rate of growth of cable (40% per year), the exact date to which these estimates correspond is important. We assume for purposes of this analysis that the figure is consistent with the 80 (or 85) million households indicated in the TRAI's National Broadband Plan. If so, this implies an upgrade cost per household of between Rs. 3.750 and 7.500, which corresponds to a one-time cost of € 55 to € 109 per household. The cost is substantial, but does not appear to be prohibitive, particularly when one considers that it enables not only broadband but also an increased number of video channels, together with more effective charging of end-users and of broadcasters/advertisers.

As regards spectrum, the TRAI's National Broadband Plan indicates, based on their modelling, that "… [a]ssuming that by 2012 an operator will deploy around 500 BTSs in

[33] TRAI, National Broadband Plans (2010).
[34] As of 1 January 2012, xe.com reports an exchange rate of € € 0.0145.

Delhi and around 150 BTSs in Nagpur and by year 2014, 1000 and 250 BTSs in Delhi and Nagpur respectively, it is seen … that the spectrum requirement in Delhi and Nagpur will be around 641MHz and 328 MHz respectively." This seems, however, to be wildly out of line with the spectrum actually available. As the National Broadband Plan also notes: "Presently 20 MHz of spectrum has been allocated to each of the three operators for [Broadband Wireless Access (BWA)]."

In the Recommendations to the National Broadband Plan, the TRAI asks for authority to review government spectrum holdings and to free up spectrum where appropriate. This is certainly a worthy goal, but based on international experience it is likely to take years to achieve consensus on the bands to free, and additional years to clear the incumbents from the spectrum.[35]

Relative to the percentage of consumers who have access to fixed or mobile broadband; the question of substitution versus complementarity is important. Many consumers will have both. A great many consumers will have a smart phone capable of Internet access (and businessmen may have an additional smart phone for business purposes), but this does not necessarily mean that fixed broadband network access at home is unimportant. Many of those who have fixed access at home are likely to also want mobile access when away from home or travelling. At the same time, the smart phone does not necessarily substitute for access on a personal computer due to the limitations imposed by the smart phone's physical form (i.e. small keyboard and screen); moreover, the use of the smart phone for high volume data transfer might well be more expensive than the use of a fixed network.

Further, the smart phone normally serves an individual, while the broadband subscription at home typically serves a family (an average of 4.2 to 4.7 individuals in India).

At the same time, we note that a fixed or mobile wireless broadband subscription – by means, for instance, of a dongle in the PC – might very well serve as a real substitute to fixed network broadband access, especially in towns where fixed access is not available.

For all of these reasons, it is misleading to simply add the number of wireless subscriptions to the number of wired in order to estimate the fraction of households who have access to broadband. The sum significantly overstates the numbers who have meaningful broadband access.[36] In the long term, the better way to estimate the fraction of Indian consumers served is by means of survey (or census) data – the most relevant indicator, in our view, is the fraction of households who *do not* have access to broadband.

Taking all of this into account, including our observations in Section 2.2, our assessment is:

[35] See J. Scott Marcus, John Burns, Phillipa Marks, Frédéric Pujol, and senior expert Prof. Martin Cave, Optimising the Public Sector's Use of the Radio Spectrum in the European Union. http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/studies/pus_2008/pus_study_2008_1_finalreport.pdf

[36] Similar concerns relate to mobile penetration numbers, which exceed 100% in many countries because many consumers have more than one subscription.

- Upgrade of cable television to digital addressable cable is extremely important, but is likely to take place more slowly than foreseen in the National Broadband Plan;
- Wireless solutions cannot serve as a replacement for wired solution in metros and in large cities (because spectrum is unlikely to be insufficient in the near to medium term), but will instead serve as an economic complement;
- Wireless solutions are likely to be adequate in villages, and may prove adequate as a full alternative to wired solutions in some towns as well;
- For now, no alternative to wireless solution exists in most towns and nearly all villages; but
- Over time, as cable subscribership continues to increase, modern cable systems may reach an increasing number of towns and will tend to provide a superior solution wherever cable is available.

4 Other public policy initiatives to consider

In this section, we briefly note relevant potential public policy initiatives that are broader than the cable issues that form the core concerns for this paper.

4.1 Demand stimulation

As with most broadband public policy initiatives, the emphasis in TRAI's National Broadband Plan is on promoting *supply* of broadband. Little attention is paid to stimulating *demand*. Given that demand stimulation (in the form of subsidised personal computers) apparently played a huge role in the enormously successful roll-out of ADSL in South Korea, it is natural to wonder whether more attention to the demand side might not be appropriate.

Recent analysis by the Florence School of Regulation (FSR)[37] on behalf of the European Independent Regulators' Group (IRG) suggests that the relationship between supply and demand promotions is complex, both in terms of relative impact and in terms of timing.

4.2 Spectrum availability

As noted in Section 2.2.4, it is vitally important to make more spectrum available, not only for fixed and mobile broadband, but also as an enabler for alternative lower bandwidth services delivered by means of voice and SMS over mobile networks.

4.3 Reconsider the structure of customs duties and other taxes

Other measures are to bring down customs duties and other taxes. The telecom sector has one of the highest tax structures in the country. The government needs to relax this regime as lower cost services will lead to higher adoption, more efficiencies in the economy and more income and service tax to the government.

The TRAI has already noted this in its plan for making cable digitised and addressable, but the principle potentially has wider applicability throughout the sector.

[37] Parcu, Belloc, Cambini, Drouard, Manganelli, Nicita, Rossi and Silvestri (2011): "Study on Broadband Diffusion: Drivers and Policies", Florence School of Regulation (FSR): Communications & Media.

5 Conclusions and recommendations

We believe that provision of broadband throughout India is a worthy goal, and we feel that TRAI's emphasis in the National Broadband Plan on a mix of DSL, cable and wireless technologies is appropriate. The National Broadband Plan recognises and seeks to address the limited and static deployment of the fixed telephone network, and the fragmented nature of a cable industry that is still mired in analogue, non-addressable technology. Nonetheless, we see numerous risks to successful implementation, not all of which are fully recognised in the National Broadband Plan, including:

- Likely delays to digitisation of cable networks due to fragmentation of the industry and a range of practical impediments;
- Insufficient spectrum for fixed and mobile wireless broadband (and for other mobile services that might complement or substitute for broadband);
- Delays that are already apparent in deployment of the NOFA national fibre-optic backhaul network;
- Lack of focus on demand stimulation, as distinct from promotion of supply;
- Burdensome tax and customs duties structures, not only for the cable industry[38] but for the sector as a whole.[39]

[38] See TRAI (2010), "Implementation of Digital Addressable Cable TV Systems in India", 5 August 2010.
[39] These are partly addressed in TRAI's approach to digitisation, ibid., but the issue is broader.