Potential benefits from sub-700 MHz spectrum in India

A report for
the GSMA

January 2015

Tim Miller
Val Jervis
John Burns
Sarongrat Wongsaroj
Tim Hogg

About Plum

Plum offers strategic, policy, regulatory and technical advice on problems relating to the use of spectrum and to the telecommunications, online and audio-visual media sectors. A London-based partnership founded in 2007, it works for governments, regulators, service providers and equipment suppliers around the world. Its advice is based on economic analysis and technical knowledge of radio engineering, which it combines with extensive market knowledge of the communications sectors to provide clear and sound analysis.

Plum Consulting, London
T: +44(20) 7047 1919, **www.plumconsulting.co.uk**

Table of Contents

1 Introduction

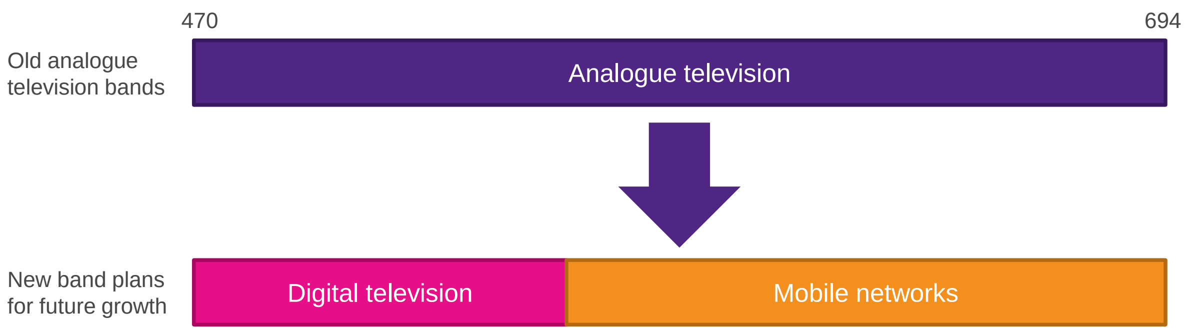
This report has been commissioned by the GSMA to consider how a potential release of spectrum in the sub-700 MHz UHF band, enabled by the movement to digital television, could lead to significant productivity improvements in the economy as a whole through an increase in availability of mobile broadband. While India has made some moves towards rolling out digital television, progress has been slow. The Government target is to have switched off analogue terrestrial television by the end of 2017, but it is unclear to what extent it will be replaced by digital terrestrial broadcasting (DTT); a recent Government expert committee recommended that DTT only be rolled out where commercially viable, with satellite the primary mean of digital public broadcasting.

The move away from analogue terrestrial broadcasting will release valuable radio spectrum for other uses. This newly cleared spectrum can be used to increase the reach and penetration of mobile broadband, which will increase productivity and welfare of the entire country. This is particularly important in India, where currently there is a significant shortage of spectrum that can be used for high-quality mobile broadband. This lack of capacity reinforces the need of the government to take action over digital transition as soon as possible.

1.1 Digital transition

Two states of the world are considered in this paper: before and after the digital transition. All spectrum below 700 MHz is reserved for use by analogue television before the transition. A portion of this will be available for use by mobile services after the transition, with the remainder available for digital television services.

Figure 1-1: Digital transition



In order to examine how this transition will impact India, two main questions must be answered:

1. What proportion of the spectrum should be reserved for digital television, and therefore how much spectrum will be available for mobile broadband?
2. How should this transition be handled?

This paper concentrates on the first of these questions, examining the broadcasting market and estimating its future spectrum needs before carrying an economic impact study of an expanded mobile broadband market. The second question requires a more detailed knowledge of which channels are currently used for analogue and digital transmission, and so is considered only briefly at the end of this paper.

1.2 Key working assumptions

A number of assumptions on the broadcasting and mobile communications markets are made by this paper. Most importantly, a requirement for the digital transition is that all channels currently broadcast over analogue will be broadcast over digital platforms (and the coverage of digital transmissions must be no worse than the coverage of analogue). Thus not only will there be no loss of welfare in terms of television content, but there may be significant advantages due to the added capacity for new channels or different types of broadcast.

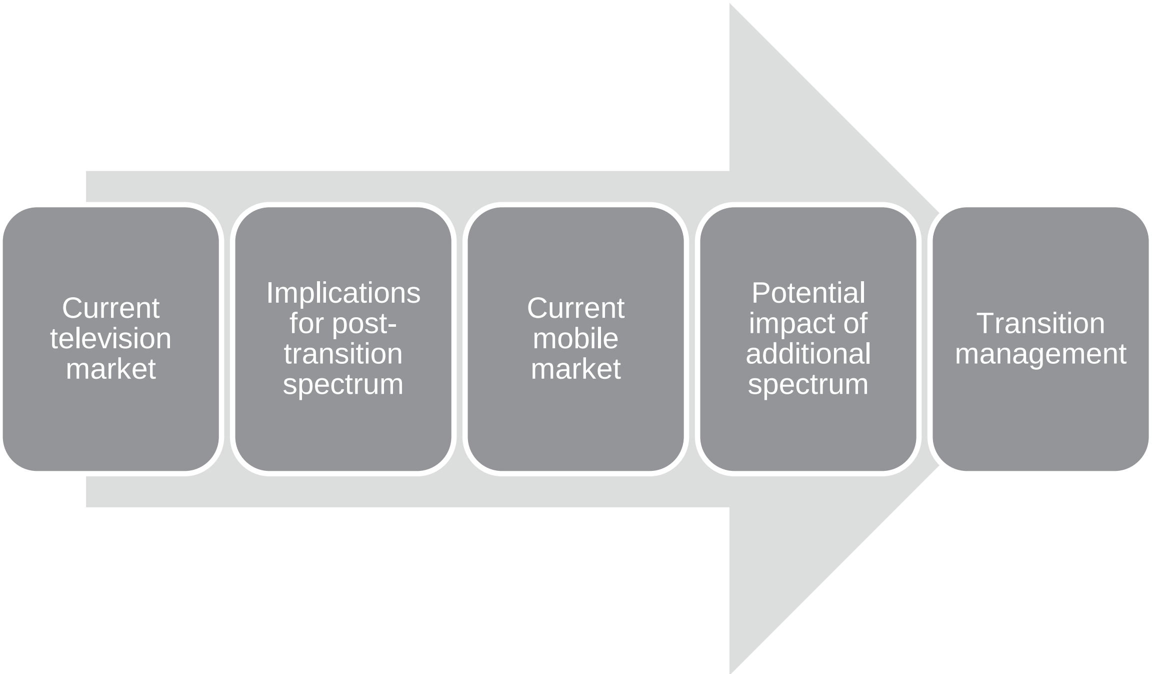
As mentioned previously, this assumption may not be necessary given some analysis of the market recommends a move to satellite broadcasting. However, in order to give a conservative estimate of the benefits that may be realised, this study assumes that terrestrial broadcasting will continue.

As Plum has received limited input from operators in the market, assumptions are also made over the amount of spectrum available to mobile operators in the event of no digital transition, market shares, data traffic demand, and so on. These are set out in more detail in Section 5.

1.3 Structure of analysis

Given these methodological assumptions, this paper is structured as shown in Figure 1-2.

Figure 1-2: Structure of analysis



- First, the current television market is examined to see what role different delivery platforms play, how many channels are broadcast, the extent of regional variations and trends in viewership.

From this analysis the minimum requirements for the post-transition television market are calculated.

- Second, the way in which a digital platform could be operated to meet these requirements is assessed. Calculating the amount of spectrum a digital platform requires means that the amount of spectrum that could be released for mobile broadband can be estimated.
- Third, the current telecommunications market is examined, looking at trends in penetration, revenues and competition compared with other countries. This overview gives the context to understand how additional spectrum may be used for mobile broadband.
- Fourth, an economic impact analysis shows how additional spectrum for mobile broadband may lead to increased usage of mobile broadband and therefore productivity gains for the economy as a whole.
- Finally, the paper sets out a conclusion on the implications for Indian spectrum policy, and the management of transition is considered, exploring how to release spectrum as quickly and efficiently as possible.

2 The broadcasting market

India is one of the world's largest TV markets in absolute terms – it has a population estimated to be around 1.27 billion[1]. According to the 2011 census, TV ownership across the country as a whole stood at 47.2%, representing some 117 million households. By the end of 2012 the total TV households were estimated to be 155 million according to industry research[2].

However, this national figure masks wide variations between individual states and cities, with (according to census data) penetration as high as 88% in the capital Delhi but falling to just 15% in Bihar. At the end of 2013, India was estimated to have 65 million pay-TV subscribers[3], of which 37 million were served by direct to home (DTH) satellite and the remainder by cable. According to the same source, total pay TV subscribers are expected to reach 165 million by 2018 and 180 million by 2023.

Doordarshan is a division of Prasar Bharati (the Broadcasting Corporation for India), which is also responsible for the state sound broadcaster All India Radio. Doordarshan claims to serve 220 million viewers terrestrially and a further 230 million via cable and satellite, however the proportion relying on terrestrial has fallen since the launch of a free-to-air DTH service, with some estimates suggesting as few as 8% of households rely solely on the terrestrial network. 72.2% of the Indian population live in some 638,000 villages and the rest (27.8%) in about 5,480 towns and urban agglomerations

2.1 Terrestrial TV

India is served by both a national public service broadcaster and a number of private commercial stations, however, only the former is authorised to provide terrestrial broadcasts. Public service broadcasting is the responsibility of Prasar Bharati, which has two divisions, All India Radio which provides sound broadcast services and Doordarshan which provides television.

Doordarshan has a three tier programme service comprising national, regional and local content. The terrestrial network comprises approximately 1,210 transmitter sites, of which 130 are high power transmitters (10 kW or more), 740 low power (typically 1 kW) and 340 very low power relays (typically 100 W or less). The network broadcasts on a mix of Band III (VHF) and Band IV (UHF) channels, sometimes using both bands at the same site (there are also a very small number of Band I transmitters).

Doordarshan provides two national TV channels over the terrestrial network, namely DD-1 (general entertainment) and DD-2 (news). DD-1 is broadcast from all the transmitter sites, which provide coverage of 91% of the population, but DD-2 is currently broadcast from only 166 sites providing approximately 50% population coverage. DD-1 provides a mix of national and regional programming, the latter being produced by local Doordarshan subsidiaries or "Kendras". A third regional analogue service is available in Chennai, Kolkata and parts of Jammu and Kashmir

All Doordarshan Kendras generate programmes in their specific regional languages which are available continuously via satellite and cable and at certain times via a regional opt-out on the national DD-1 channel. There is also a wider regional service covering the predominantly Hindi speaking

---

[1] See http://www.indiaonlinepages.com/population/india-current-population.html

[2] Media Partners Asia report: Asia Pacific Pay TV and Broadband Market 2012

[3] Source: "India Pay-TV and Broadband—Future Trends", Media Partners Asia, 2014

states of Uttar Pradesh, Bihar, Jharkhand, Chattisgarh, Madhya Pradesh, Rajasthan, Haryana and Himachal Pradesh. These programmes are produced in the capitals of the respective states between for up to five hours a day and are also relayed by the DD-1 network.

2.1.1 Digital transmissions

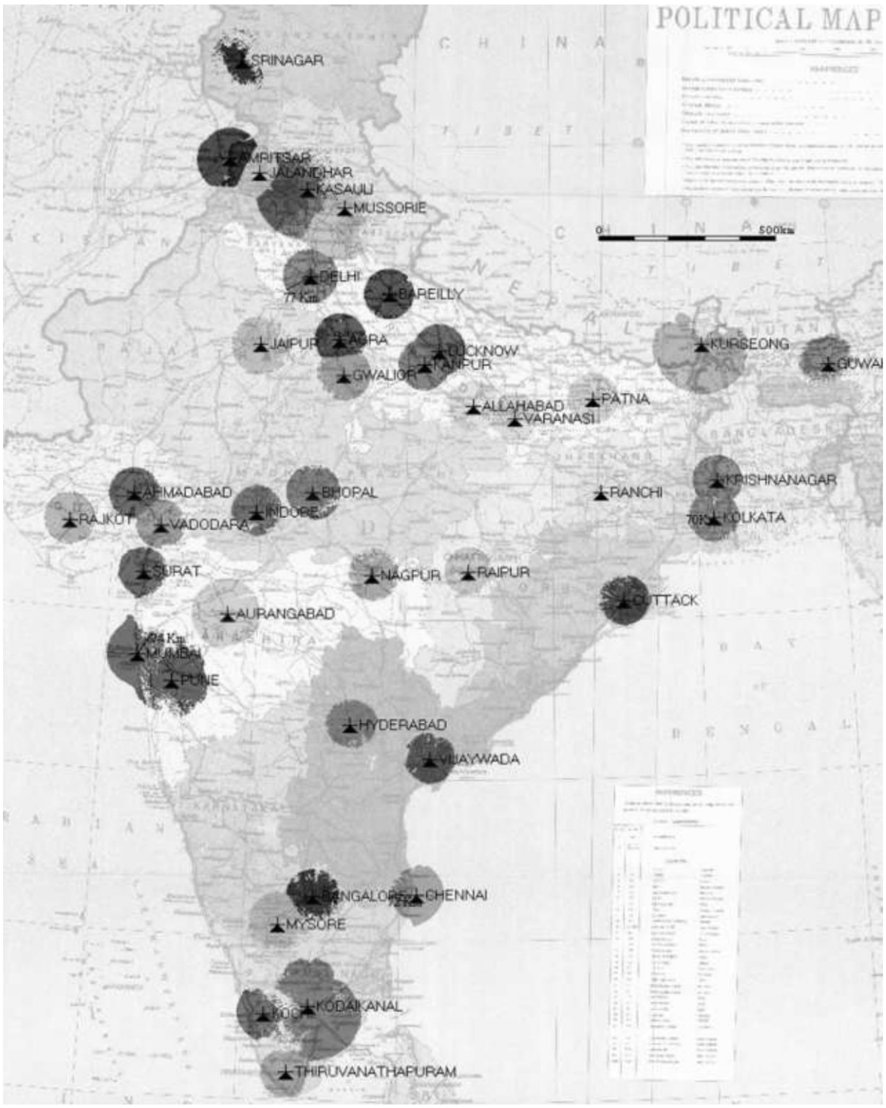
To gain experience in DTT technology, Doordarshan commissioned four digital transmitters in Delhi, Mumbai, Kolkata & Chennai (accounting for approximately 2.5% of the national population) in January, 2003, for an experimental service. These transmitters are still operational, each providing a single multiplex using the original DVB-T standard and carrying 4 – 5 standard definition TV channels. Coverage is scheduled to extend to a further 15 cities during 2014 and to reach 40 cities in 2015. The rollout schedule is shown in Table 2-1 below. According to Doordarshan, the 40 transmitters will provide a combined population coverage of 38% by the end of 2015. In addition, the existing four digital transmitters will be upgraded to provide HD broadcasts. The new transmitters will be SD only initially but will have the capacity for HD upgrade at a later date. A further 590 low power digital transmitters are planned to follow after 2015.

Table 2-1: Planned rollout of DTT transmitters in India, 2014 -15

Schedule	Cities served
Already on air	Chennai, Delhi, Kolkata, Mumbai
2014	Ahmedabad, Aurangabad, Bangalore, Bhopal, Cuttack, Guwahati, Indore, Jallandhar, Lucknow, Patna, Raipur, Ranchi, Srinagar, Hyderabad, Trivandrum,
2015	Agra, Kurseong, Allahabad, Mussorrie, Amritsar, Mysore, Bareilly, Nagpur, Gwalior, Pune, Jaipur, Rajkot, Kanpur, Surat, Kasauli, Vadodara, Kochi, Varanasi, Kodaikanal, Vijayawada, Krishnangar

Source: Frequently Asked Questions published by Doordarshan

Figure 2-1: Projected geographic coverage of DTT in India by end of 2015



Source: Doordarshan

The first of two transmission contracts to support the DTT expansion were awarded to Harris Broadcast (since rebranded as GatesAir) in January 2014. As noted above, this will provide a HD service in the four major metropolitan areas (Chennai, Delhi, Kolkata and Mumbai). The second contract covers the rollout of digital services to other regions, as listed in Table 2-1 above. Initially, these transmitters will carry standard definition channels but they can be quickly upgraded to HD when required. All of the new transmitters will use DVB-T2 technology to maximise capacity.

The Government's aim is to complete the transition to digital nationally by the end of 2017. However, whilst this would involve the closure of the current analogue terrestrial services, it is unclear to what extent these would be replicated nationally in digital form. Whilst some reports have indicated that Doordarshan is planning to upgrade its entire transmission network to digital and in doing so to deliver up to 600 channels across the country[4], an expert panel commissioned by the Government to review

[4] Hindustan Times, 25th September 2013.

public service broadcasting has recommended that satellite should be the primary transmission medium in the future and that digital terrestrial transmission should only be deployed in areas where it can be shown to be economically viable. The expert panel's report[5] noted that currently 92 per cent of Indian TV households access to television through cable and satellite systems (Cable and DTH), with only 8% relying on terrestrial transmission. This proportion is expected to decline significantly as more viewers switch to cable or DTH services, particularly since the launch of the free-to-air Doordarshan DTH service.

The report argues that this presents a strong case for expediting the closure of analogue terrestrial TV and adoption of Doordarshan's existing satellite DTH service DD Direct as the primary mode of transmission. It is claimed that such a move would result in considerable cost saving (up to INR 13 bn of capital expenditure and over INR 6 bn annual operating costs), whilst offering a wider content variety compared to terrestrial broadcasts. The report also notes that Doordarshan's channels are also transmitted through private DTH and cable and satellite operators.

2.2 Mobile TV

Doordarshan launched a trial mobile TV service using the DVB-H standard in Delhi in May 2007, offering a bundle of eight TV channels and operating in UHF Band IV (channel 26). The number of TV channels was increased to 16 a year later. The service appears to be still operational.

In September 2014, Doordarshan announced plans to launch a free-to-air mobile TV service in Delhi and Mumbai in January 2015. Private media companies will be approached to help provide the DVB-T2 based service, which will gradually be rolled out across the nation, according to Jawhar Sircar, chief executive of DD's operator Prasar Bharti. Viewers will initially be able to access the mobile service through a dongle, though Doordarshan hopes this technology will become embedded inside mobile devices in the future. It is understood that that this service will be delivered over the same DVB-T2 multiplex as that used for HDTV in the four metro areas and for SDTV in the other regions; an additional frequency will not be required.

2.3 Cable TV

Commercial provision of cable TV services in India began in 1992 with the launch of the Star TV and Zee TV networks. Cable TV is now the dominant platform for TV viewing in India (though DTH satellite is growing), accounting for 96 million households, or 62% of all TV households in India at the end of 2012. Recent consolidation in the industry has created a number of regional monopolies, which has led to a recent investigation by the regulator TRAI[6]. The cable market in India is currently extremely fragmented, with over 60,000 registered operators across the country, most of them local providers covering small neighbourhoods. The market is made up of multi system operators (MSOs) who operate cable networks at multiple locations and local cable operators (LCOs) serving a specific neighbourhood.

Historically many cable TV services in India were analogue but regulations have been introduced to digitise all services by the end of 2015. The process has raised concerns about eventual

[5] "Report of the Expert Committee on Prasar Bharati", January 2014.

[6] See "Recommendations on Monopoly / Market dominance in cable TV services", TRAI, November, 2013

displacement of smaller multi system operators (MSOs) and the marginalisation of local cable operators (LCOs), who will in future be required to relay content from the MSOs as only the latter are able to operate the necessary conditional access systems, Already, aggregate investments worth around INR 20 bn have been incurred by large national MSOs toward acquisition of smaller regional MSOs and LCOs. The Ministry of Information and Broadcasting recently announced (in September 2014) new dates for phasing out of analogue cable TV in the country with final switchover delayed to the end of 2016. The four metros of Delhi, Mumbai, Kolkata and Chennai shifted to digital by 31 October 2012 and the second phase, which included 35 cities with a population of more than one million, was completed by 31 March 2013[7].

It was reported in September 2013[8] that Cable TV operators in more than 40 major cities had to show twenty-one Doordarshan, and three other, channels to their consumers in cities where digitisation had been implemented.

Table 2-2: Mandatory programmes to be carried by cable and DTH operators

Ch	Name of the Channel	Genre
1	DD National	General Entertainment (Hindi)
2	DD News	News and Current Affairs
3	DD Bharati	Infotainment
4	DD Urdu	Infotainment
5	DD Sports	Sports
6	DD India	Infotainment
7	DD Kashir	General Entertainment (Regional)
8	DD Punjabi	General Entertainment (Regional)
9	DD Gimar	General Entertainment (Regional)
10	DD Sahyadri	General Entertainment (Regional)
11	DD Saptagiri	General Entertainment (Regional)
12	DD Malayalam	General Entertainment (Regional)
13	DD Podhigai	General Entertainment (Regional)
14	DD Chandana	General Entertainment (Regional)
15	DD Bangla	General Entertainment (Regional)
16	DD North East	General Entertainment (Regional)
17	DD Bihar	General Entertainment (Hindi)
18	DD Uttar Pradesh	General Entertainment (Hindi)
19	DD Rajastan	General Entertainment (Hindi)
20	DD Madhya Pradesh	General Entertainment (Hindi)

[7] See “Study of Digital Switchover Plan in SATRC” presented at the 2nd SATRC Meeting, March 2014.

[8] Source: PTI

Ch	Name of the Channel	Genre
21	DD Oriya	General Entertainment (Regional)
22	Gyan Darshan Channel	Infotainment
23	Lok Sabha Television Channel	News and Current Affairs
24	Rajya Sabha Television Channel	News and Current Affairs

2.4 Satellite TV

Satellite direct-to-home (DTH) services have become increasingly popular as an alternative platform for TV channel distribution. There are six private pay DTH operators in the country, namely, Dish TV, TATA Sky, Airtel, SUN, Videocon and Reliance. The national public service broadcaster Doordarshan also provides a free DTH service which carries all of the local and regional Doordarshan channels. The government has recently approved the expansion of Doordarshan's direct-to-home (DTH) satellite TV network from 59 to 97 channels. At the end of 2012 there were 54.5 million DTH subscribers, equivalent to 35% of total TV households.

At the end of 2013, Doordarshan had 20 million satellite receivers in circulation[9]. The Ku-Band service is provided via the INSAT-4 platform, which also broadcasts the main national and regional channels at C-Band.

There is a mandatory requirement for all DTH service providers to include the channels listed in Table 2-2 above irrespective of the other channels that they plan to provide.

2.5 IPTV

IPTV services are available from a number of Indian broadband operators and offer a mix of real-time and on-demand content. The services are typically offered as part of a triple-play package including voice, broadband and TV. However, availability is patchy due to the limited availability of reliable high speed broadband connectivity.

One of the largest providers, which launched in 2009, was Smart TV, which operated under the brand MyWay and claimed to provide IPTV services in 54 Indian cities, accounting for half the population (although only a very small proportion of these will have access to the broadband speeds necessary to support IPTV). The service was offered in partnership with the fixed line operators MTNL in Delhi and BSNL elsewhere in India. However, it was reported in 2011 that the company had withdrawn from its arrangement with BSNL[10] and two years later the Delhi MTNL IPTV service also ceased[11]. Reliance is currently offering IPTV in parts of Mumbai and claims to be planning to roll out to other major cities in the future. Bharti Airtel is currently offering a service in Delhi and Bangalore

Currently less than 1% of broadband connections in India deliver more than 10 Mbps and less than 5% deliver more than 4 Mbps, In 2012, fixed broadband penetration was reported as 7% of households, hence it is unlikely that more than about 0.5% of households currently have access to the

[9] NexTV Asia Pacific

[10] “BSNL's partner pulls the plug on IPTV service”, The Hindu, 17th November 2011

[11] MTNL web site

broadband speeds capable of supporting IPTV. As digitisation of cable networks is the primary facilitator of improved broadband connectivity in India, it is likely that any future growth in IPTV take-up will be as part of the cable operators' multi-play offerings rather than other players in the market.

3 Spectrum use

The use of other platforms for broadcast may be one reason why the rollout of digital terrestrial television in India has been slow. Whilst there has been a trial DTT service in the four largest cities since 2003 and Doordarshan announced plans for national rollout in 2010, there were no concrete moves towards expansion until earlier this year. The placing of contracts for the first phase of national rollout infrastructure will bring DTT to approximately a third of the population, but no firm date has been set for when or even whether coverage will be extended further, nor for the closure of the existing analogue service.

The strong prevalence of cable and satellite (DTH) reception in India, along with the low cost of reception equipment, makes the economic case for national DTT rollout questionable. Even in remote it is likely that DTH or local cable distribution of transcoded satellite broadcasts would provide a more cost-effective solution than attempting to cover the entire country with DTT, especially given the existing analogue terrestrial network covers only 92% of the population.

3.1 Current utilisation

As noted previously, only the public service broadcaster Doordarshan is authorised to use the terrestrial broadcast spectrum. Currently transmission is in Bands I (47-68 MHz, channels 2-4), III (174-230 MHz, channels 5-12) and IV (470-590 MHz, channels 21-35). Band V (590-694 MHz, channels 36–48) is currently reserved for future digital and mobile TV services but it is unclear at this stage whether these will be brought into use.

The existing digital transmitters operate in Band IV and our understanding is that this will also be the case for the 36 new transmitters referred to above (though this still needs to be confirmed).

Current utilisation of frequencies by the analogue network is as follows[12]:

- 8 transmitters operating in Band I (0.6%)
- 1,034 transmitters operating in Band III (73.0%)
- 373 transmitters operating in Band IV (26.4%)

Of the 1,217 transmitter sites, 1,043 (85.7%) carry only the main DD-1 channel. 166 sites carry two channels (DD-1 and DD-2) and 10 carry three channels (the third channel being either a digital or special regional service). Only two sites – Delhi and Kolkata currently carry four channels. The fourth channel in Delhi is an experimental mobile (DVB-H) service, whilst in Kolkata it provides a local (Bangla) channel.

In Kolkata, all three bands are currently in use – Band I for the main DD-1 channel, Band III for DD-2 and the regional Bangla channel and Band IV for the digital service. Several other sites use a mix of Band III and Band IV channels.

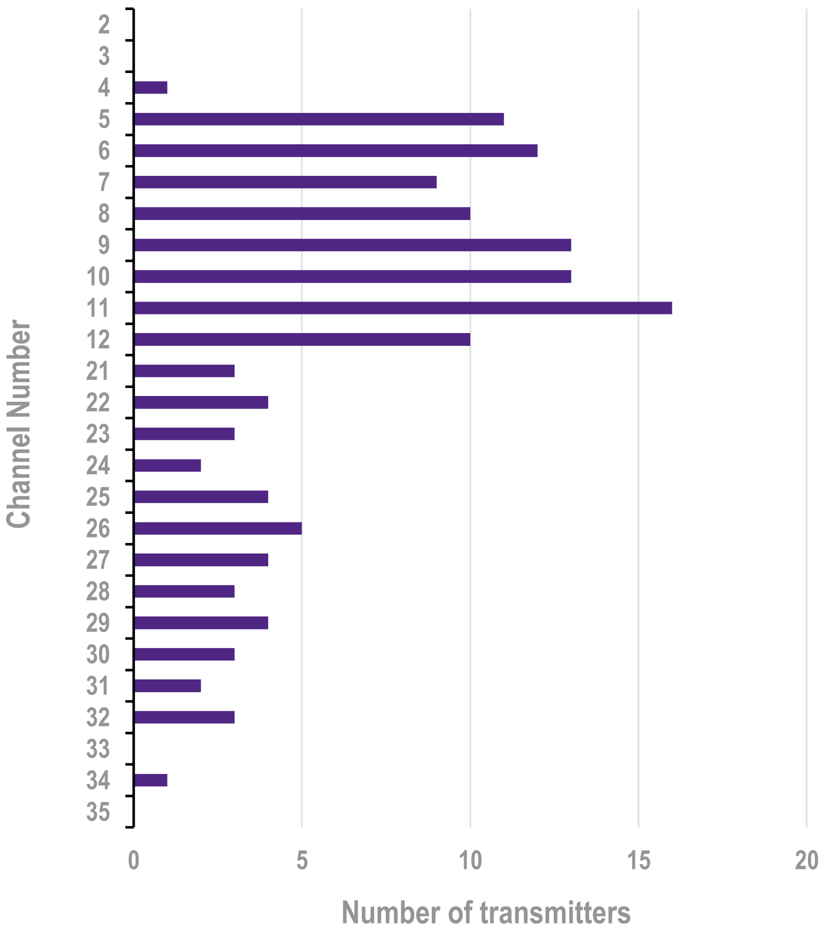
Once the current digital rollout plan (40 sites) is completed, the number of three-channel sites will increase to 40, there will be two four-channel sites (Aurangabad and Srinagar), two five-channel sites

[12] "Mesh Network for Rural Broadband Coverage Using TV White Spaces in India" for WP5A Seminar on Cognitive Radio System and the Use of White Spaces. It was also noted that most of the UHF band spectrum is white spaces in most places. It was calculated that 11 out of 15 channels (>70%) could be freed up by reassignment of TV channels.

(Mumbai and Chennai) and two six-channel sites (Delhi and Kolkata). This includes an extra UHF channel in Chennai, Delhi, Kolkata and Mumbai for the digital HD service.

Specific frequency data has only been ascertained for a limited number of sites (approximately 10%), however the 70-30 distribution between Bands III and IV at the sites where data is available appears to be consistent with the overall distribution of sites between bands identified above, implying that this is a reasonable representation of the national picture. The distribution of frequencies by channel across these sites is as follows:

Figure 3-1: Distribution of frequencies by channel for limited number of transmitter sites in India



Source: Plum Consulting

Other uses of UHF band V currently are understood to be Defence and low capacity analogue microwave links operated by BSNL in the range 622-712 MHz. It is likely that the latter have been largely replaced by digital links in higher bands.

Despite the broader move towards digitisation, there is some ongoing expansion of the analogue network in border regions. For example, it was announced in March 2014 that the Indian Government plans to install eight terrestrial transmitters along the border with Nepal, which could enable the broadcaster Doordarshan to provide content to 65% of the population of Nepal.

3.2 Future requirements for digital transmission

Terrestrial broadcasting in India is limited to the national public service broadcaster, Doordarshan, which outside the major metropolitan areas currently transmits no more than two analogue channels. Digital services area currently limited to the four main metro areas but are due to be extended to a total of 40 sites serving approximately 38% of the population by 2015. Whilst the current digital service, which launched on a trial basis in 2003, uses the original DVB-T standard, the expanded coverage will use DVB-T2 technology, which will provide the option of HD and mobile TV reception. Our understanding is that a single DVB-T2 digital multiplex will operate at each site, with the current four DVB-T multiplexes being retained in Chennai, Delhi, Kolkata and Mumbai.

Both cable and DTH reception has been growing rapidly and the latter has been boosted significantly by the launch of the free-to-air Doordarshan DTH service, which carries almost 100 channels. Given the ubiquity of satellite coverage, that mandatory carriage of Doordarshan services over cable networks and the relatively low cost of providing the receiving equipment for free to air DDH reception it is questionable whether it will be economic to digitise Doordarshan's entire terrestrial transmitter network. Even if digitisation does proceed nationally, the current utilisation of UHF frequencies is sufficiently low that it should be possible to accommodate a national digital service entirely within Band IV (470 – 590 MHz), leaving Band V available for other services. The release of Band V for mobile would provide 80 MHz of spectrum.

A similar report for Pakistan[13] has concluded that it should also be possible to release the entirety of Band V in Pakistan for mobile. This should provide significant benefits in managing the potential for cross-border interference compared with the scenario of high power TV broadcasting transmitters being deployed in one country and mobile in the other. In this instance there could be significant geographic areas near the border where it would not be possible to deploy a mobile network operating in the same band.

In the longer term, when the analogue service is switched off, there may be a good case for migrating digital TV to Band III, though this may depend on the extent to which the mobile TV market develops, the extent to which the UHF network has been rolled out and whether receiving equipment is compatible with this band. Thus, to be conservative, this study considers that the entirety of Band V will be released to mobile providing the potential of 80 MHz of spectrum.

3.2.1 Further benefits of digital switch-over

As well as the benefits that may arise from mobile use of freed-up spectrum, there are additional benefits that arise from use of digital transmission for terrestrial television. These are not quantified in this paper, but the potential benefits should not be underestimated.

- A greater selection of channels can be delivered to the poorest sections of society, without the need for pay-TV subscriptions or satellite equipment. This can allow increases in educational content and local cultural content.
- Additional technologies such as subtitles and supplementary text which extend accessibility and can provide viewers with more information and interactivity.
- Digital EPGs mean viewers can track when programmes are shown, and potentially set alerts.

[13] Plum Consulting for the GSMA, 'Potential benefits from sub-700 MHz spectrum in Pakistan', January 2015

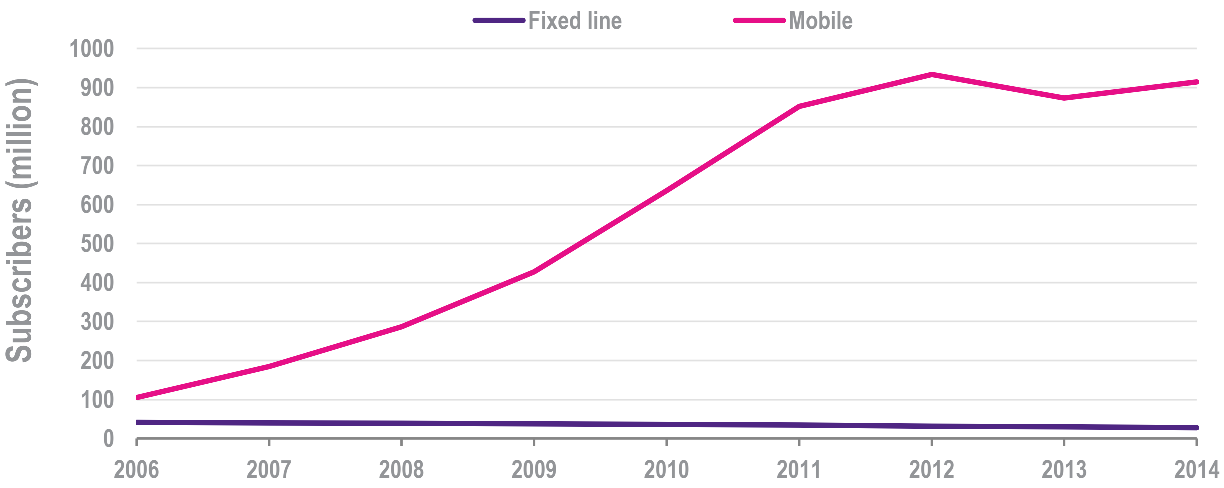
- Encryption allows pay-TV channels, which will allow the platform to carry more profitable content.

4 The telecommunications market

The mobile market in India has experienced significant growth in the last ten years; as shown by Figure 4-1, the number of mobile subscribers is now over 900 million. This success story is in contrast to fixed line telephony where the number of subscribers has fallen. Figure 4-1 also shows the dip in mobile subscribers in 2013 caused by the deletion of inactive subscribers, and how the underlying growth continued into 2014.

The Indian mobile market is very competitive with currently 14 operators offering GSM services and six operators offering CDMA services[14]. In the second quarter of 2014 the number of CDMA subscribers fell by 1.54 million across India – the growth of mobile subscribers is in GSM services. As of June 2014 there were eight providers of wireline services in India[15], with the largest (BSNL) having 64% of the market share.

Figure 4-1: Telephony subscriptions (Q2 of each year[16])



Source: Plum Consulting, TRAI

4.1 Mobile market

The Indian mobile market is separated into a number of regional markets because spectrum licences are awarded on a regional basis. There are 22 regions, or circles, which vary in size, geography and demographics. Operator spectrum holdings vary by circle and the only operators to provide services in all circles are Bharti, Vodafone, IDEA, Reliance and Aircel[17].

There is also a large difference between the mobile market in urban and rural areas, with the rural market growing faster than the urban market; the proportion of subscriptions that are in rural areas has

[14] Reliance, Tata, Sistema, BSNL, MTNL and Quadrant

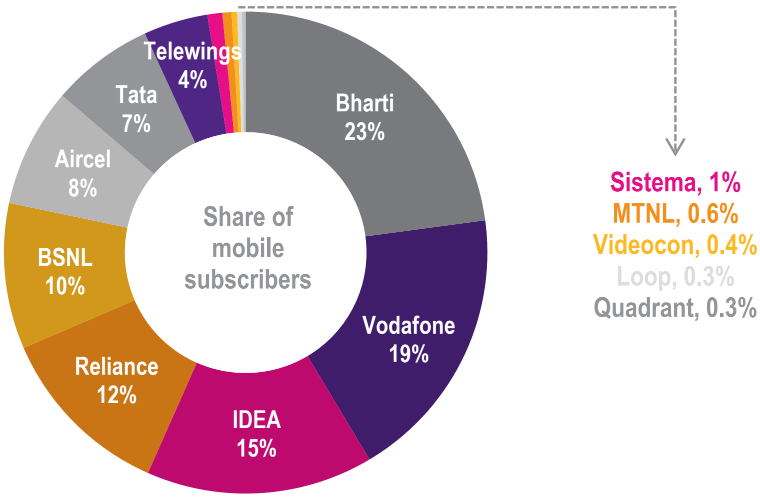
[15] BSNL, MTNL, Bharti, Tata, Reliance, Quadrant, Sistema and Vodafone, with BSNL, Tata, Reliance and Sistema providing services in some rural areas

[16] The dip in GSM subscribers in 2013 was due to a one-off deletion of inactive subscribers by operators.

[17] A merger between BSNL and MTNL, proposed at various times, would create another national provider, with MNTL offering services in the two circles (Delhi, Mumbai) that BSNL does not.

risen from 33% (Q2 2010) to 41% (Q2 2014)[18]. As of June 2014, mobile penetration was 70.3%, however, this masks significant regional variation; mobile penetration in urban areas averaged 140% while in rural areas it averaged 44%[19]. Operators vary in their rural presence; for example, in June 2014 54% of Vodafone's subscribers were in rural areas compared to only 25% for Reliance[20].

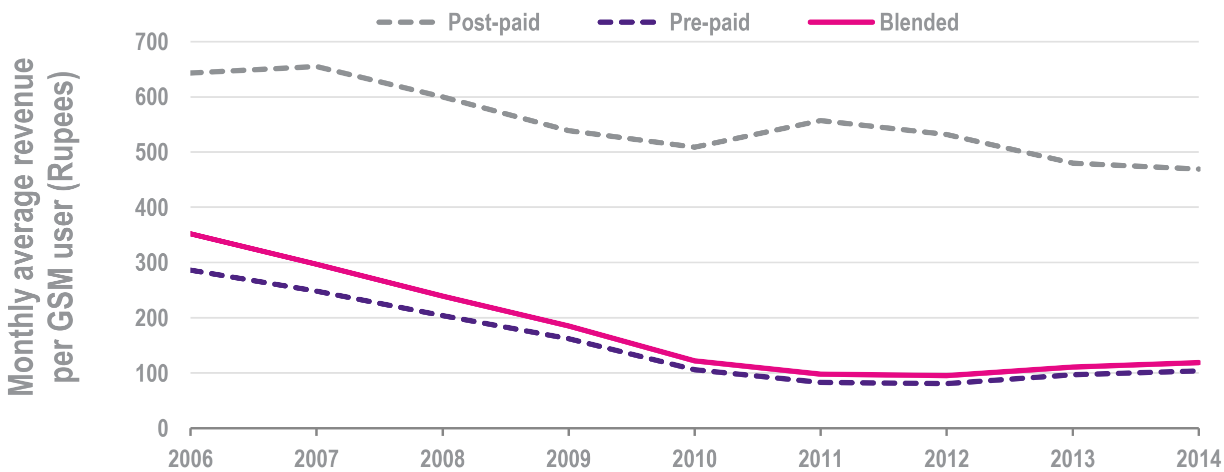
Figure 4-2: National mobile market shares by subscribers (Q2 2014)[21]



Source: Plum Consulting, TRAI

No operator has as much as a quarter of the mobile market share and there is competition in every region of India. Figure 4-2 shows how there are multiple players competing for the growing market. This competitive pressure has driven down consumer prices.

Figure 4-3: GSM ARPU (Q2 of each year)



Source: Plum Consulting, TRAI

[18] TRAI Indicator Reports

[19] TRAI Indicator Reports

[20] TRAI Indicator Reports

[21] Reliance includes the shares of both Reliance Communications Ltd and Reliance Telecom Ltd.

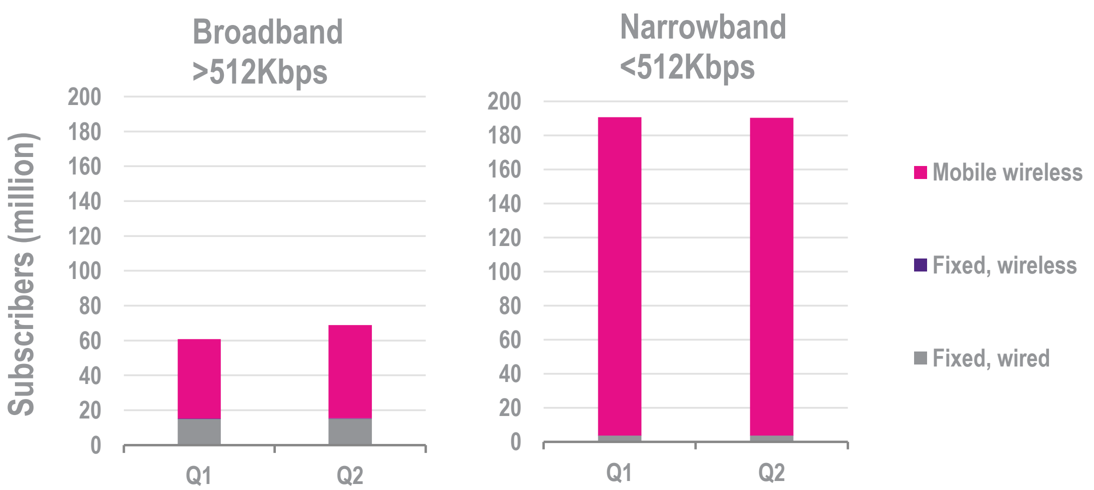
As shown by Figure 4-3, average revenue per user fell by over 70% between 2006 and 2011, before growing marginally between 2011 and 2014, possibly as a result of the deletion of inactive subscribers. Again, there is significant variation by circle with the city circles (almost entirely urban) having an ARPU 28% greater than the average (Q2 2014)[22]. Post-paid ARPU is significantly greater than pre-paid ARPU. In 2014 96% of subscriptions were pre-paid, although this was 87% in metro circles.

4.2 Internet penetration

Internet access is a key driver of economic growth; the more Indians have access to the Internet, especially broadband, the more the Indian economy will grow. As shown in Figure 4-4, wireless (mobile, dongle) is the main way in which Indians access the Internet, with 187 million narrowband subscribers and 53 million broadband subscribers (Q2 2014). In the second quarter of 2014 the number of broadband subscriptions rose by 8 million, while the number of narrowband subscriptions fell by half a million: upgrades account for a small proportion of broadband growth.

Fixed line Internet services have four million narrowband subscribers and 15 million broadband subscribers, while fixed wireless services (Wi-Fi, Wi-Max, Point-to-Point, VSAT) have under half a million subscribers in total.

Figure 4-4: Internet subscriptions in 2014

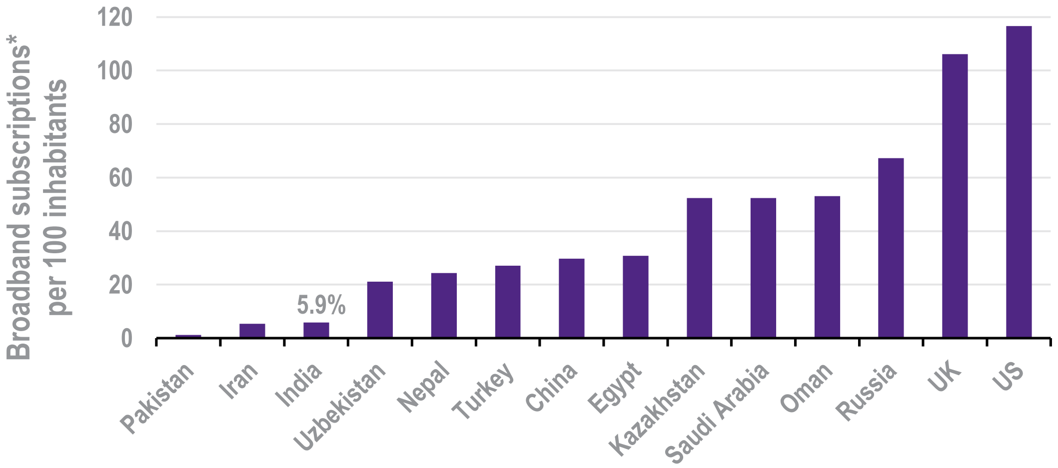


Source: Plum Consulting, TRAI

Internet subscribers as a proportion of population are 21%, although it varies significantly by circle; from 9% in Bihar to 78% in Delhi. With low rates of Internet penetration and narrowband services still making up 73% of the subscriptions, there is a lot of growth waiting to be unlocked.

[22] TRAI Indicator Reports

Figure 4-5: Broadband penetration



Source: Plum Consulting, ITU
*The ITU defines broadband as 256 kbit/s

Broadband penetration in India is lower than most countries; a few other countries are shown in Figure 4-5. This means there is a big opportunity to for economic growth. The quickest and most efficient way to increase Internet penetration in India will be to allow mobile broadband to grow, but this requires additional spectrum.

5 Economic impact of released spectrum

When operators have additional spectrum, it can be used to expand mobile network capacity. In particular, the increased frequency bandwidth can be used to extend mobile broadband service to those who may have previously been priced out. An increase in deployment of mobile broadband, leading to an increase in broadband service take-up, can have significant impacts on the GDP through two key channels.

- The first is the direct injection of funds into the economy as operators deploy new infrastructure. This can support the creation of new jobs, and multipliers, such as the creation of and consumption broadband-based or online services, in the economy lead to further rises in GDP.
- The second is the adoption of broadband by businesses and consumers. The adoption of broadband by enterprises can enhance multifactor productivity, which contributes to GDP growth. Similarly, households which use broadband will have better access to information and services which could help to improve its members' job prospect and labour productivity and increase household income.

5.1 Benefit estimation methodology

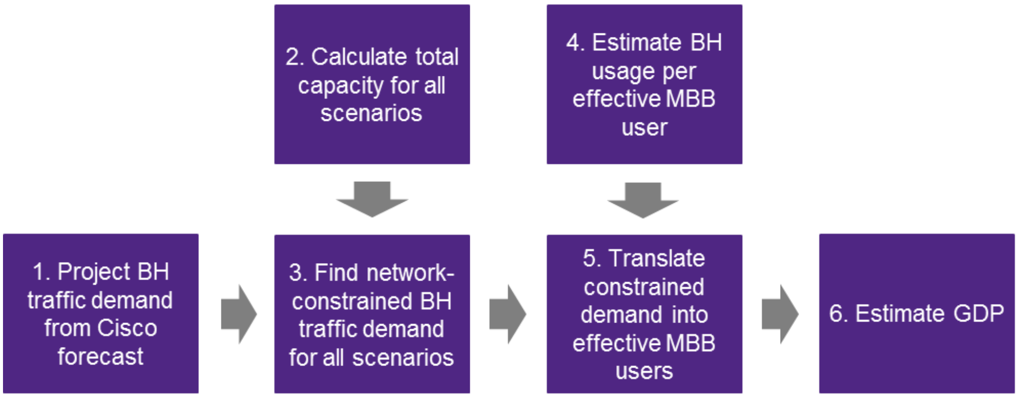
The methodology for estimating the economic impact of an increase in spectrum availability in this report is based on the observed positive correlations between broadband penetration and GDP growth. There is extensive literature which confirms this relationship, and a comprehensive review of the relevant studies can be found in a Plum's study for the GSMA on Egypt[23].

The model is driven by the understanding that by having access to additional spectrum, mobile operators will expand their network capacity more rapidly since they can do this at a relatively low cost compared to rolling out new base station sites. This will enable extra demand for mobile broadband to be met, and there will be more mobile broadband users contributing to an overall increase in the country's broadband penetration. This means that where there is greater spectrum availability, there will be more broadband users than under a scenario where no additional spectrum is made available in future.

Figure 5-1 is a flow diagram of the steps that the model follows to derive the economic impact of new spectrum release for mobile broadband in GDP terms. This process is repeated for each scenario to be modelled. The GDP estimates for different spectrum release scenarios are then computed, and the difference between these represents the change in GDP when one spectrum scenario is implemented over another.

[23] http://www.plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

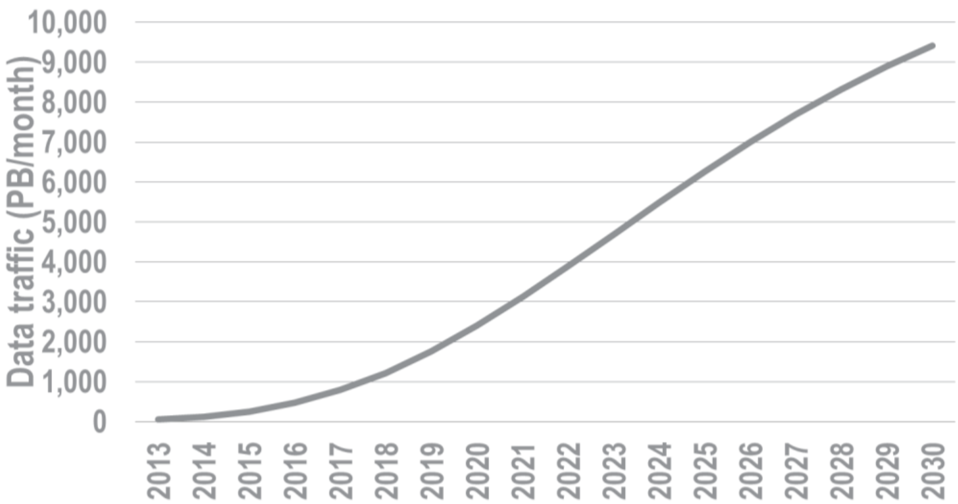
Figure 5-1: Flow diagram of steps for GDP calculation



Data to populate the model has been derived from a number of public sources. Where assumptions have been made, these have been presented to the GSMA so that they may be sense checked.

First, the total mobile data demand in the market in the absence of supply-side constraints has been derived based on Cisco VNI 2014 India forecasts. These assumptions over data growth are shown in Appendix A.

Figure 5-2: Unconstrained mobile traffic in India



Source: Cisco VNI 2014, Plum Analysis

Next, the total capacity in the network is calculated based on technical parameters and the spectrum holdings expected for the operators. These data inputs are set out in Appendix A, and have been computed from public sources. When network capacity falls below the level set out in Figure 5-2, demand is said to be constrained. It is this constrained demand that determines the number of mobile broadband users that can be accommodated in the market. This will differ from scenario to scenario, depending on how much additional spectrum is released and how it is distributed amongst operators.

The constrained demand computed through Step 1 to Step 3 is converted into the number of effective mobile broadband users that there could be in the market in the absence of supply-side constraints. To do this monthly usage per subscriber has been estimated based on operator's data on traffic per MBB subscriber in the market, traffic volumes for mobile band compatible devices from Cisco VNI 2014, and estimates used in a previous studies for similar developing economies. The constrained demand expressed as the number of mobile broadband users allows the model to calculate the change in broadband penetration[24] for each scenario.

To estimate the effect of mobile broadband on GDP growth under each scenario, the model makes use of the relationships in established studies[25] between the increase in broadband penetration and the change in GDP or the change in GDP growth. For this study, the model uses a conservative estimate of an increase of 0.5 percentage points in annual GDP growth rate for a rise of 10 percentage points in broadband penetration. This enables the model to produce a time series of GDP for the modelling period for each spectrum release scenario. Once the GDP time series for each spectrum scenario including the base case is obtained, the change in GDP between the base case (without additional spectrum) and the alternate scenario for each year can be computed.

5.2 Modelling assumptions

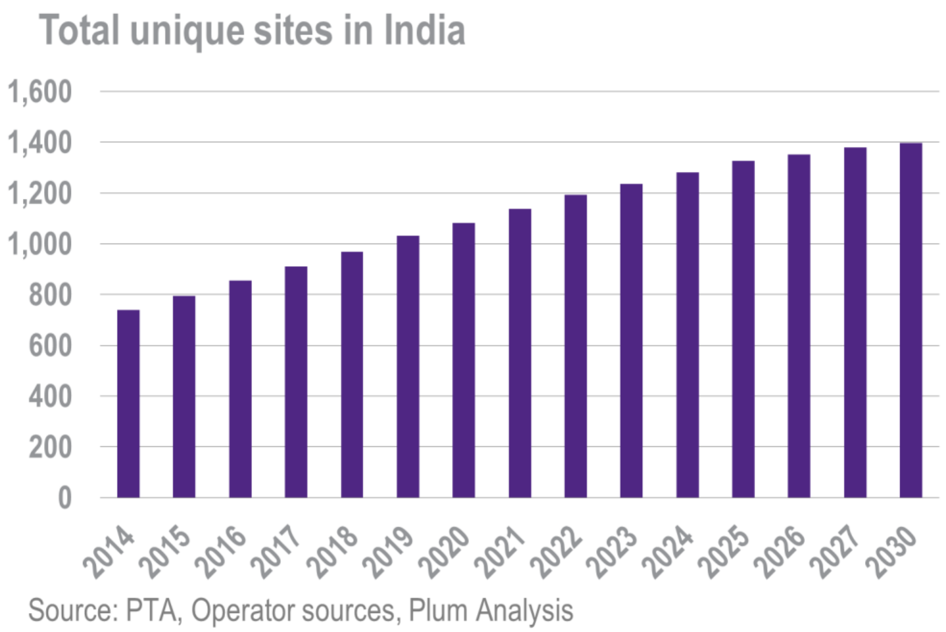
Since only high-level data is available in the public domain, a number of assumptions have been made around several key parameters that determine the total network capacity. These assumptions apply to both the base case and the alternate scenario, and they are as follows:

- The same number of operators as in 2013 will continue to offer service in each circle throughout the modelling period.
- Sites and spectrum are distributed evenly amongst all operators in each circle. The total site count in each circle is obtained from a DoT's document published by the ITU. Figure 5-3 shows the projection of total site count in India based on this information.

[24] Existing fixed broadband connections and included and their growth is extrapolated into the future in all cases to ensure that the effect of the increase in broadband penetration due to greater availability of mobile broadband is accurately captured.

[25] The key findings of some of these studies have been summarised in a previous Plum report on Egypt for the GSMA: http://www.plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

Figure 5-3: Projected total number of unique sites in India

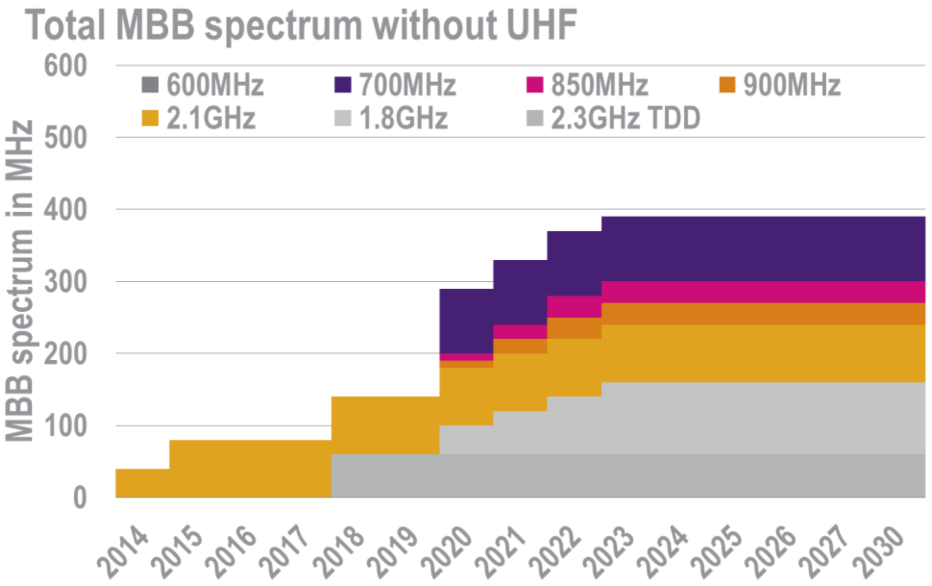


The key assumptions that differentiate the base case and the alternate scenario are discussed below. All other assumptions including technical parameters and demographic assumptions, which are the same under all scenarios, can be found in Appendix A.

5.2.1 The base case

As mentioned in Section 5.1, the benefit in GDP terms that accrues to each scenario is represented by the change in GDP from the base case. In this base case, it is assumed that no 600 MHz spectrum is released. Only spectrum in the 700 MHz, 850 MHz, 900 MHz, 1800 MHz and 2100 MHz bands are available for use in providing mobile broadband (MBB) service. Figure 5-4 shows the total amount of spectrum assumed to be available and used by operators to offer MBB service during the modelling period.

Figure 5-4: Total spectrum used for MBB in the base case



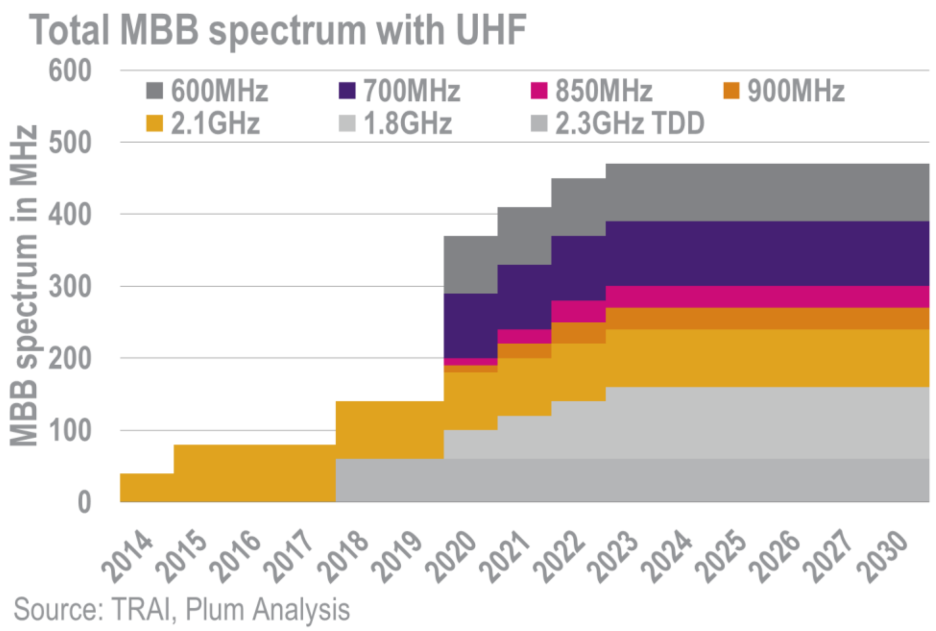
Source: TRAI, Plum Analysis

5.2.2 Alternate scenario

In the alternate scenario, it is assumed that the 600 MHz UHF band is allocated to mobile service and assigned to operators to provide MBB from 2020 in addition to bandwidths in the 700 MHz, 850 MHz, 900 MHz, 1800 MHz, 2100 MHz and 2300 MHz bands. When released, the 600 MHz UHF band is assumed to be used in supplemental-downlink mode, which allows the entire bandwidth to be used for expanding downlink capacity. This is more efficient than a paired configuration given that downlink traffic is expected to continue to account for more than 70% of total mobile data traffic and there will be sufficient uplink capacity in other bands to accommodate all uplink traffic.

Figure 5-5 shows the total amount of spectrum that is assumed to be available and used by operators for the provision of MBB service during the modelling period under the alternate scenario.

Figure 5-5: Total spectrum used for MBB in the alternate scenario



It is assumed that mobile service over the additional spectrum commence in 2020 – after clearance of analogue television and the potential movement of digital television and commercial roll out of the mobile network. However, it will take a few years for operators to deploy the necessary infrastructure in all areas, and so the maximum capacity from the band is not reached until 2023.

This delay in the use of released spectrum is a common issue with regulatory spectrum awards. It is, therefore, important for spectrum to be assigned to operators well in advance of anticipated need for more capacity. Demand for MBB service could be choked off, if spectrum is not made available in a timely manner. This will have the effect of slowing down the growth of the broadband market and hence GDP. Thus, it is crucial that the government in India acts as soon as possible to release the UHF spectrum to mobile operators. If spectrum were made available before 2020, the potential benefits would be greater than estimated in this paper.

5.3 Quantitative results

The model shows that given the amount of spectrum and the network infrastructure available for mobile broadband service, there will be capacity constraint throughout the modelling period. However, the capacity shortfall can be alleviated with the release of the 600 MHz UHF spectrum in 2020. This allows take-up of mobile broadband service to increase contributing to a greater rise in broadband penetration in the alternate scenario compared to the base case. Figure 5-6 shows the levels of broadband penetration that are achievable under the base case and the alternate scenario.

Figure 5-6: Broadband penetration under base case and the alternate scenario

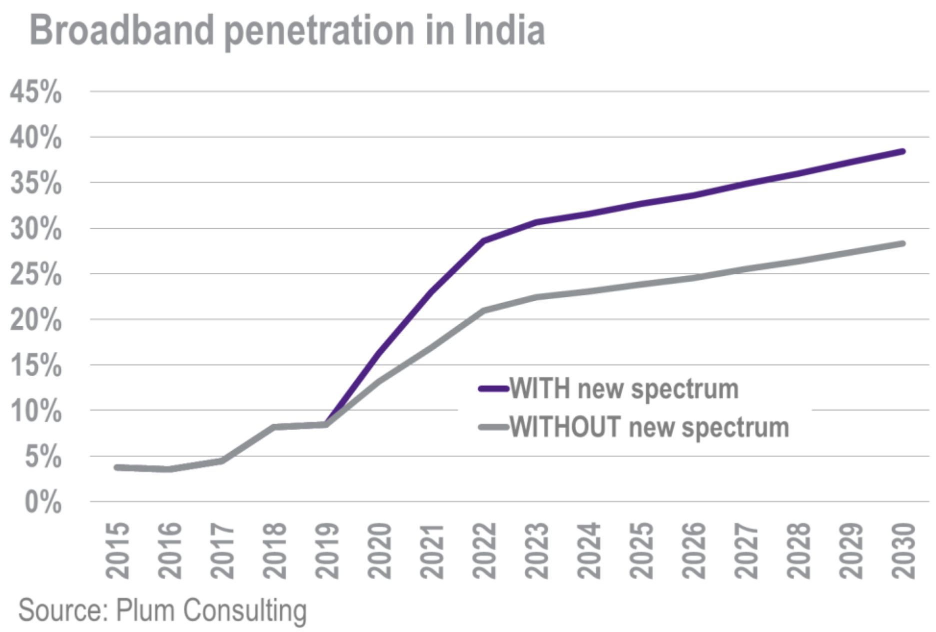


Figure 5-7 shows the time series of GDP that would be realised under the base case without 600 MHz UHF spectrum and the alternate scenario with 600 MHz UHF spectrum. By 2030, the GDP in the alternate scenario is 1.4% higher than the base-line GDP in the base case. A snapshot of the GDP in 2030 for the base case and the alternate scenario is shown in Figure 5-8.

Figure 5-7: GDP time series for the base case and the alternate scenario (INR bn, 2013 prices)

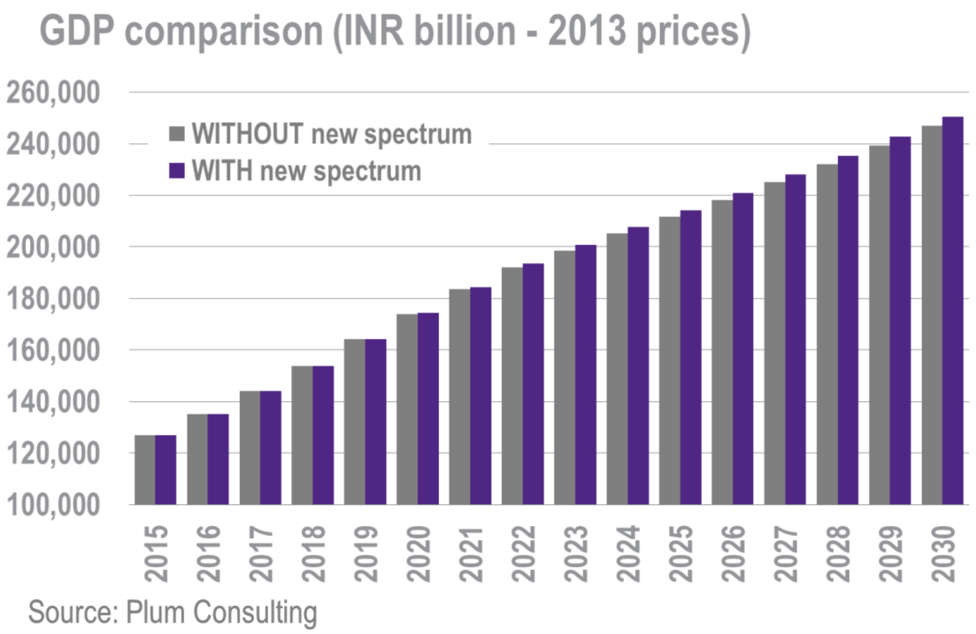
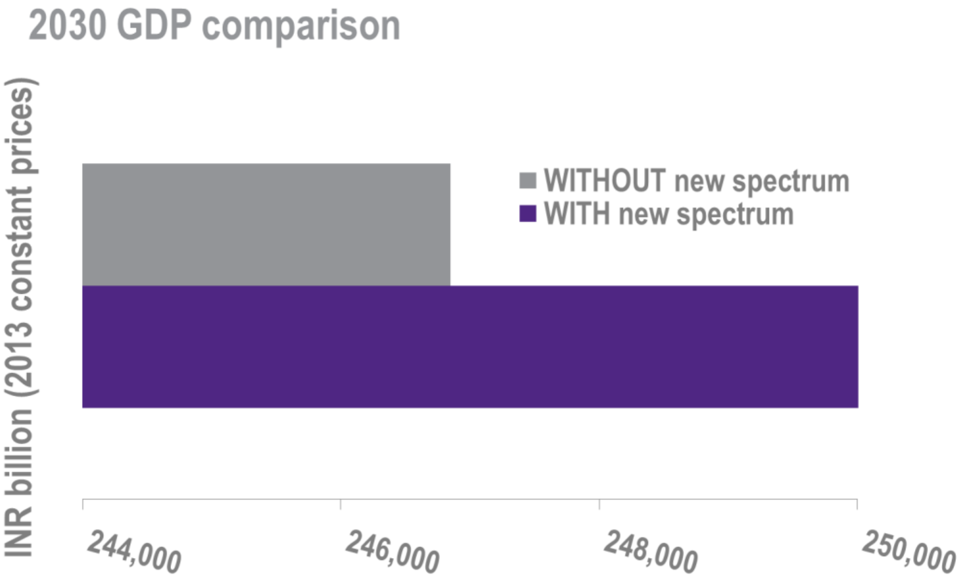


Figure 5-8: Comparison of 2030 GDP between the base case and the alternate scenario



Source: Plum Consulting

Discounting the time series of the GDP between 2015 and 2030 back to 2015 yields an NPV of GDP of:

- INR1,977,400bn for the base case,
- INR1,991,400bn for alternate case

This means that the total economic benefit in terms of additional GDP in NPV terms could be up to **INR14,000bn** (US$226bn) if the 600 MHz UHF spectrum is can be allocated to mobile service.

However, as there are already capacity constraints on networks, any delay in awarding extra spectrum will reduce the benefit that will be felt. It is crucial that the regulator acts quickly.

6 Implications for spectrum policy

There are substantial economic benefits from moving terrestrial television services from the current analogue platforms to digital transmission. This report estimates that the expansion of mobile broadband services could grow the Indian economy by up to 1.4% by 2030.

Indian broadband penetration is currently low and given the low penetration of fixed line telecommunications, mobile broadband is crucial to improving this. The Government of India should act to ensure that this transition can take place as soon as possible, particularly given the slow progress towards digital broadcasting.

Therefore, the sooner the Government can release spectrum to mobile operators, the sooner these benefits will be felt.

Spectrum release

It is unclear exactly how much spectrum will be released for mobile, but this study believes that at least 80 MHz would be made available after the digital transition; the low number of analogue channels currently broadcast would theoretically be able to all be carried on a limited number of multiplexes in UHF Band IV. However, the Government may be able to consolidate terrestrial broadcasting further to release more spectrum for mobile broadband, by:

- Defining multiplexes for DTT which do not use the whole of Band IV, or
- Potentially using VHF spectrum (Band III) for DTT, therefore releasing the whole of Band IV, or
- Using satellite (DTH), rather than DTT, as the primary transmission mode for public service broadcasting, therefore also releasing the whole of Band IV and possibly Band III.

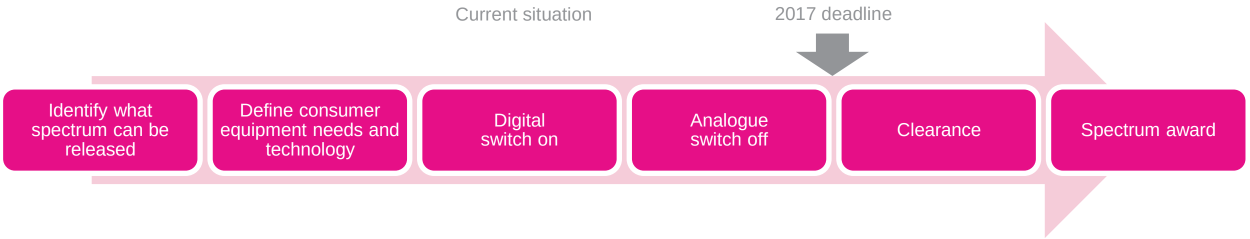
It is important to take account of decisions made by neighbouring countries. For example, if India were to allocate spectrum in a different way to Pakistan and Bangladesh, cross-border interference would render mobile broadband unusable in large areas of the country.

7 Transition management

This report has demonstrated that there are significant benefits that may be realised if the Indian authorities act to release sub-700 MHz UHF spectrum to mobile broadband in the near future. This will be achieved by completing the digital transition for terrestrial television services. However, it is not clear whether the Government's expert committee's advice will be taken and whether digital public service broadcasting will primarily be provided using satellite rather than DTT.

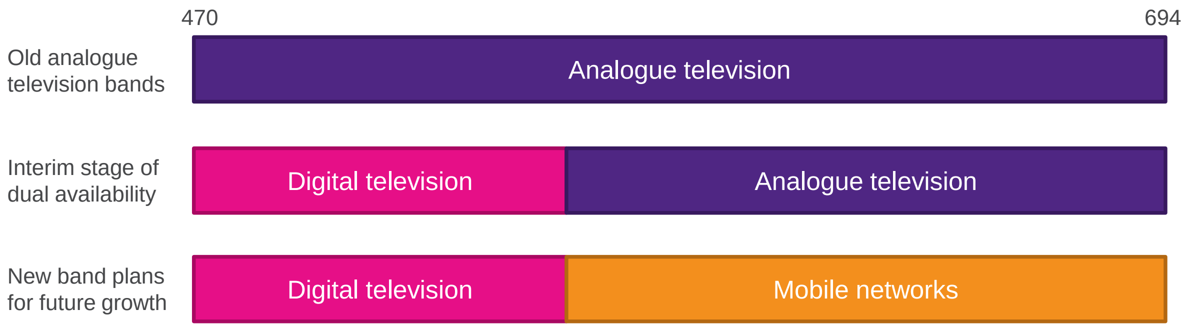
The digital transition requires six steps, as shown in Figure 7-1. This study has identified that spectrum will be able to be released, and has made some assumptions over the technologies to be used. However, without swift action over the progress of the digital switch on, it will be difficult to complete analogue switch-off which was planned the end of 2017.

Figure 7-1: Digital transition



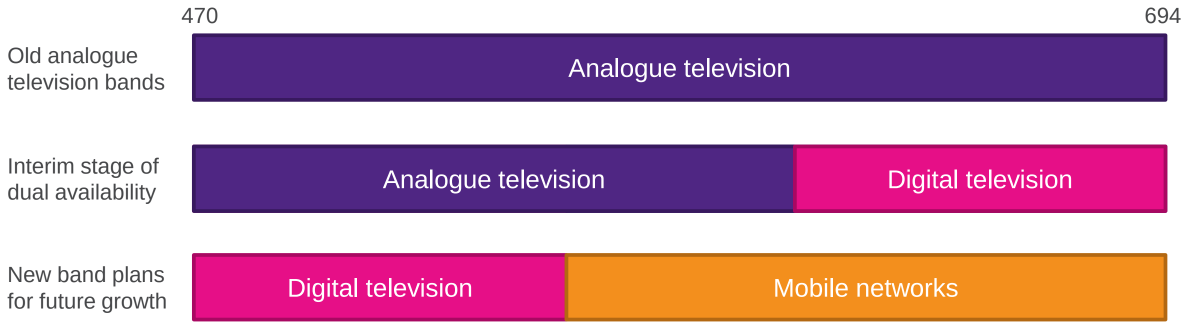
The Government must establish the best path to reach its end goals based on the existing markets. The type of consumer antenna equipment prevalent in India will influence the transition sequence from analogue to digital terrestrial television. Full-band antennae receive transmissions over the entire UHF band: if full-band antennae are generally used then it would be optimal to prevent a retuning exercise by introducing digital television at the lower end of the band.

Figure 7-2: Preferred transition sequence



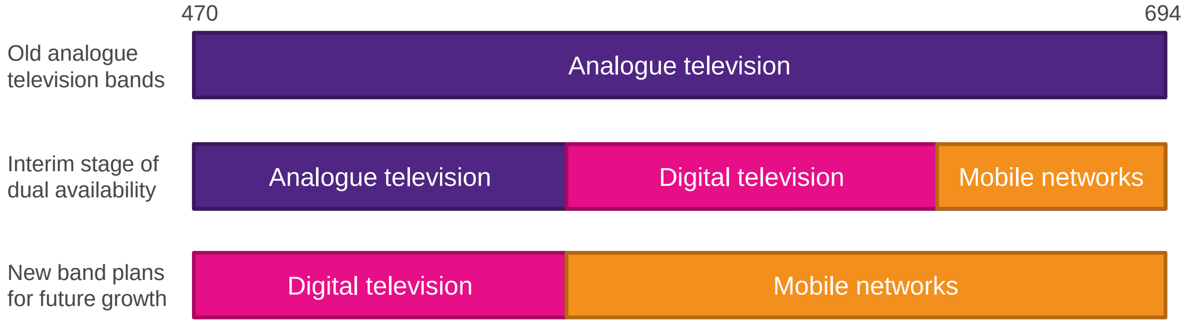
If less-capable antennae, configured for only part of the band, are prevalent then the digital transmission may have to start at the top of the band so that those with less-capable equipment do not immediately lose analogue television. After analogue switch-off, digital can then move to its permanent home, as shown in Figure 7-3.

Figure 7-3: Alternative transition sequence



In an ideal situation, all existing analogue broadcasts will already be in a restricted frequency range, which would allow both digital broadcasts and mobile networks to be set up immediately, as shown in Figure 7-4.

Figure 7-4: Transition sequence with immediate mobile capability



It may even be possible to rearrange the location of analogue and digital transmission during the interim stage to prevent the need for a retuning exercise. Without comprehensive study of the national broadcasting frequencies, however, it is impossible to determine the optimum path.

Appendix A: Modelling assumptions

The following tables contain values for inputs to the model. The information sources are listed alongside the values.

A.1 Demographic assumptions

Parameter	Value used	Source
Population (million) 2013 2015 2020 2025 2030	 1,233 1,258 1,322 1,389 1,460	Plum's projection based the India's 2011 census and the UN's expected growth (World Urbanization Prospects: 2014 Revision)
Urban population percentage	Varies by circle	Plum's projection based the India's 2011 census
Average number of people per household 2013 - 2022 2023 - 2030	 5 4	Estimated based on ITU Yearbook's statistics to between 2003 and 2012
Maximum % of urban population that can afford mobile broadband service	100%	Plum's estimate assuming that there is no affordability constraint – i.e. the market is competitive and prices are sufficiently low when there is no supply constraint

A.2 Market and traffic demand assumptions

Parameter	Value used	Source
Number of operators (Base Case)	Varies by circle (6-10)	TRAI
Mobile population coverage (2013-2025) Urban Rural Blended	 100% 92% - 94% 92% - 94%	Plum's estimate
Country's monthly mobile data usage volume 2013 2015 2020 2025 2030	 52 PB 255 PB 2,406 PB 6,263 PB 9,417 PB	Estimated based on pro-rating Plum's Gompertz-curve projection of Cisco VNI 2014 forecasts for India

Parameter	Value used	Source
Monthly data usage volume per effective mobile broadband subscriber 2013 2015 2020 2025 2030	 1.2 GB 2.4 GB 5.6 GB 7.2 GB 8.3 GB	Plum's estimates based on previous socioeconomic study on Pakistan for Qualcomm and Cisco VNI's reported usage for tablets, smartphones and computers in 2013 for MEA
Number of fixed broadband subscriptions (million) 2013 2015 2020 2025 2030	 16.3 18.7 24.7 30.7 36.7	Estimated based on a straight-line extrapolation of the TRAI's statistics for fixed wireless broadband lines from their 2013 annual report

A.3 Network assumptions

Parameter	Value used	Source
% of traffic from occasional users 2013 2015 2020 2025 2030	 15% 15% 10% 8% 5%	Plum's estimate
% traffic in busy hour	10%	Plum study for Qualcomm[26]
% traffic in downlink	90%	Plum study for Qualcomm
% utilisation of capacity for reasonable quality of service for end user	60%	Plum study for Qualcomm
Downlink:Uplink timeslot ratio for TDD band	2:1	Plum study for Qualcomm
Sectors per BTS	3	
Number of mobile technologies in use 2013-2014 2015-2030	 2 3	Plum's estimates based on technology global deployment trends and India's specific circumstances
Spectrum efficiency (bps/Hz) 2013 2015 2020 2025 2030	 0.45 0.65 1.10 1.35 1.60	Plum's estimate based on discussion with equipment vendors as used in Plum's study for Qualcomm on LSA in 2.3 GHz band[27]

[26] http://www.plumconsulting.co.uk/pdfs/Plum_Aug2013_Pakistan_3G.pdf

[27] http://www.plumconsulting.co.uk/pdfs/Plum_Dec2013_Economic_benefits_of_LSA_2.3_GHz_in_Europe.pdf

Parameter	Value used	Source
Year on year change in spectrum efficiency (bps/Hz)	0.05 – 0.10	Plum's estimate based on discussion with equipment vendors
Number of base stations by circle at end-2013		2013 mid-year figures from DoT
Andhra Pradesh	60,285	
Assam	14,152	
Bihar	44,283	
Delhi	30,900	
Gujarat	45,950	
Haryana	17,604	
Himachal Pradesh	7,021	
Jammu & Kashmir	11,115	
Karnataka	54,307	
Kerala	32,658	
Kolkata	19,609	
Madhya Pradesh	46,423	
Maharashtra	64,354	
Mumbai	25,535	
North East	8,634	
Orissa	20,795	
Punjab	26,959	
Rajasthan	35,560	
Tamilnadu inc Chennai	67,319	
Uttar Pradesh East	45,176	
Uttar Pradesh West	37,883	
West Bengal	30,080	
Growth rate of site count		Plum's estimate based on international trend
Urban areas	1% - 10%	
Rural areas	2%	
Ratio of urban site count to rural site count		Plum's estimate based on data from a previous Plum's economic impact studies for other developing countries adjusting for rural to urban population split in some circles
Delhi & Mumbai	100:0	
All other circles	60:40	
% of rural sites that are mobile-broadband ready[28]		Plum's estimate
2013	0%	
2015	20%	
2020	50%	
2025	50%	
2030	50%	

[28] This is defined as a site that has a backhaul link capable of high-speed data transmission.

A.4 Economic assumptions for GDP growth model

Parameter	Value used	Source
Boost to GDP growth rate per additional 10pp broadband penetration	0.5 percentage points	Plum study for GSMA[29]
Duration of for which the growth rate boost persists	3 years	Plum study for GSMA
Discount rate	5%	Estimated based on World Bank's reported real interest rate for the country between 2004 and 2013
GDP at 2013 constant prices (INR billion)		IMF World Economic Outlook database April 2014 edition
2013	113,216	
2016	135,156	
2019	164,260	
15-year base-line GDP yearly growth rate[30]	3.0%	Plum's estimate based on IMF's near-term projection
Tax as a percentage of GDP for the modelling period	8%	Estimated based on averages calculated using information on GDP and tax available from African Statistical Yearbook 2014[31]

A.5 Spectrum assumptions

It is assumed that, in future, all new GSM 900/1800 devices will be UMTS-compatible (given the current trend) and 1800 MHz LTE handsets will be cheap enough, so that operators can gradually re-farm their 900 MHz and 1800 MHz spectrum for use with mobile broadband from 2020. The assumptions below are made based on the total quantum of spectrum available to operators that Plum is aware of and possible release dates of new spectrum in the press. The same amount of spectrum is assumed to be made available for MBB (3G or more advanced technologies) for all circles.

A.5.1 Total MBB spectrum available if no UHF spectrum is released

It should be noted that the bandwidth in each row of the tables below refers to the total bandwidth in each spectrum band that is available for **mobile broadband service**. It is assumed that the 900MHz and 1800MHz bands will be re-farmed gradually from 2G services from 2020. Additionally it is assumed that 2300MHz spectrum will be released or repurposed for use with mobile technology, while it is expected that the 2600MHz will not be released for mobile in India.

[29] http://www.plumconsulting.co.uk/pdfs/Plum_Aug2013_Pakistan_3G.pdf

[30] The rate at which GDP is expected to grow in the absence of contribution from broadband

[31] http://www.afdb.org/en/documents/publications/african-statistical-yearbook/

A.5.1.1 Urban areas

Band	2013	2015	2020	2025	2030
600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
700MHz	0 MHz	0 MHz	90 MHz	90 MHz	90 MHz
850MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
900MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
1800MHz	0 MHz	0 MHz	40 MHz	100 MHz	100 MHz
2100MHz	40 MHz	80 MHz	80 MHz	80 MHz	80 MHz
2300MHz	0 MHz	0 MHz	60 MHz	60 MHz	60 MHz
2600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
Total	**40 MHz**	**80 MHz**	**290 MHz**	**390 MHz**	**390 MHz**

A.5.1.2 Rural areas

Band	2013	2015	2020	2025	2030
600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
700MHz	0 MHz	0 MHz	90 MHz	90 MHz	90 MHz
850MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
900MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
1800MHz	0 MHz	0 MHz	40 MHz	100 MHz	100 MHz
2100MHz	40 MHz	80 MHz	80 MHz	80 MHz	80 MHz
2300MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
2600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
Total	**40 MHz**	**80 MHz**	**230 MHz**	**330 MHz**	**330 MHz**

A.5.2 Total MBB spectrum available if UHF spectrum is released

A.5.2.1 Urban areas

Band	2013	2015	2020	2025	2030
600MHz	0 MHz	0 MHz	80 MHz	80 MHz	80 MHz
700MHz	0 MHz	0 MHz	90 MHz	90 MHz	90 MHz
850MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
900MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
1800MHz	0 MHz	0 MHz	40 MHz	100 MHz	100 MHz

Band	2013	2015	2020	2025	2030
2100MHz	40 MHz	80 MHz	80 MHz	80 MHz	80 MHz
2300MHz	0 MHz	0 MHz	60 MHz	60 MHz	60 MHz
2600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
Total	**40 MHz**	**80 MHz**	**370 MHz**	**470 MHz**	**470 MHz**

A.5.2.2 Rural areas

Band	2013	2015	2020	2025	2030
600MHz	0 MHz	0 MHz	80 MHz	80 MHz	80 MHz
700MHz	0 MHz	0 MHz	90 MHz	90 MHz	90 MHz
850MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
900MHz	0 MHz	0 MHz	10 MHz	30 MHz	30 MHz
1800MHz	0 MHz	0 MHz	40 MHz	100 MHz	100 MHz
2100MHz	40 MHz	80 MHz	80 MHz	80 MHz	80 MHz
2300MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
2600MHz	0 MHz	0 MHz	0 MHz	0 MHz	0 MHz
Total	**40 MHz**	**80 MHz**	**310 MHz**	**410 MHz**	**410 MHz**