AFFORDABLE INTERNET ACCESS: THE COST CHALLENGE

1.1 Introduction

In its 2017 Affordability Report[1], A4AI found that the average price of 1GB prepaid mobile broadband, when expressed as a percentage of average per capita Gross National Income (GNI) varied between 0.84% in North America and 17.49% in Africa. For the majority of developing and less developed countries the price of Internet access failed to meet the 2% affordability target[2] - being 4.25% in Asia-Pacific and 3.71% in Latin America / Caribbean.

At the most fundamental level, the affordability target can only be met either by enhancing incomes or by reducing Internet prices. The income side of the equation is beyond the scope of this paper, but it is worth noting that incomes are likely to rise as a direct result of Internet prices falling because better and greater use of the Internet will boost productivity, albeit slowly. Equally it is worth noting that as incomes rise there is likely to be a greater propensity to spend on Internet access, and this boost in demand will result in lower costs and lower prices.

On the other side of the equation, over time Internet prices will be driven down to cost-based levels, at least in markets with effective competition between service providers. Policies to improve the affordability of the Internet therefore need to:

- acknowledge the real costs of providing Internet access that have to be recovered through Internet prices;
- understand the major components that comprise those costs; and
- identify the various policy levers that may be used to reduce the unit costs of service.

To address these issues A4AI has conducted a review of relevant industry costs in developing nations. The analysis considers the role that geographic and demographic factors play in determining the cost, and indirectly the price, of Internet access. Also, by identifying how each of the key cost components varies with Internet volumes, the analysis allows for the framing of effective policy responses so as to improve affordability. However, the analysis also demonstrates that some cost differences between countries are irreducible – being a result of factors outside the control of service providers, regulators and policy makers – and hence that significant national variations in Internet affordability are likely to be an enduring feature unless there are significant subsidies in some countries.

1.2 Summary findings

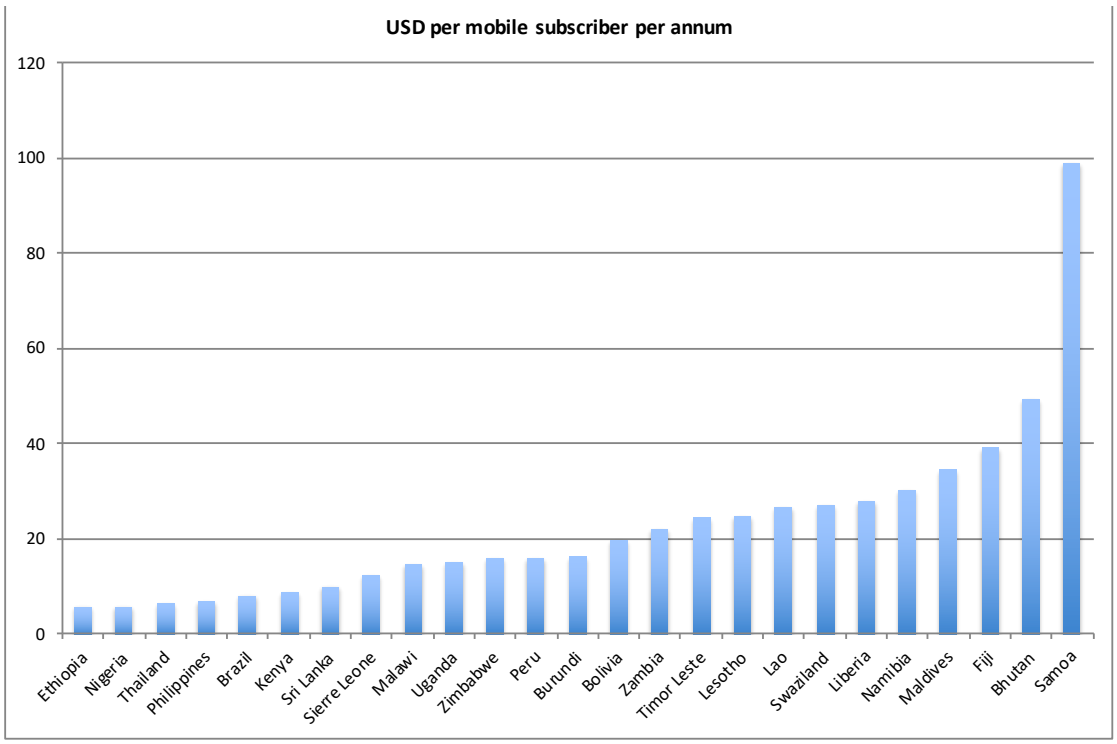
The cost of delivering Internet access varies substantially between countries, irrespective of national policy, the effectiveness of competition or average Internet usage levels. Cost analysis, based on a typical usage profile applied across a benchmark group of developing

[1] http://a4ai.org/affordability-report/report/2017/#

[2] Although the UN affordability target is 500MB of data at 5% of GNI, A4AI supports the more stringent target of 1GB at 2% of GNI – the "1 for 2" target.

countries shows that the normalized network cost[3] of Internet access can vary widely between $6 and $99 per mobile subscriber[4] per annum.

Figure 1: Normalized Network Cost[3] of Internet Access by Country



Author's calculations based on data from World Bank Databank (2017) and Telegeography - Submarine Cable World Map, 2018.

Why are the cost variations so great? In answering such a question it is tempting to jump straight into "solutions mode", identifying policy levers that can be pulled so as to ameliorate the situation. Many of these solutions are described in the Affordability Report: public WiFi, community networks, infrastructure sharing and universal service funds. However, the costs shown in Figure 1 assume that such solutions are implemented to the same extent in all the countries. Despite this, there are vast differences in the unit costs of

[3] The "normalized network cost" is the theoretical cost per user assuming that all current mobile subscribers were to make average usage of the Internet. This measure is not ***actual cost*** because it does not take account of different levels of usage per subscriber in the different countries. Also, it should not be confused with the ***price*** of Internet access paid by end users. The end user price will be higher. How much higher will depend on a range of factors such as: the expected return on capital employed, the efficiency of service providers and hence the level of retail mark-up on network costs, and the extent of competition. The purpose of using the "normalized network cost" is to identify cost differences between nations that cannot be eliminated through the actions of operators, regulators or users.

[4] Only mobile subscribers are considered because only mobile provides mass access to the Internet in most developing countries.

supply and, consequently, there will inevitably be vast differences in the retail price of Internet access.

This is because of a range of critical exogenous factors, based on geography and demography, which benefit some countries and disadvantage others. Put simply, the odds are stacked against countries that:

- Have a low population density;
- Are landlocked; or
- Are an island nation (i.e. an archipelago comprising multiple islands).

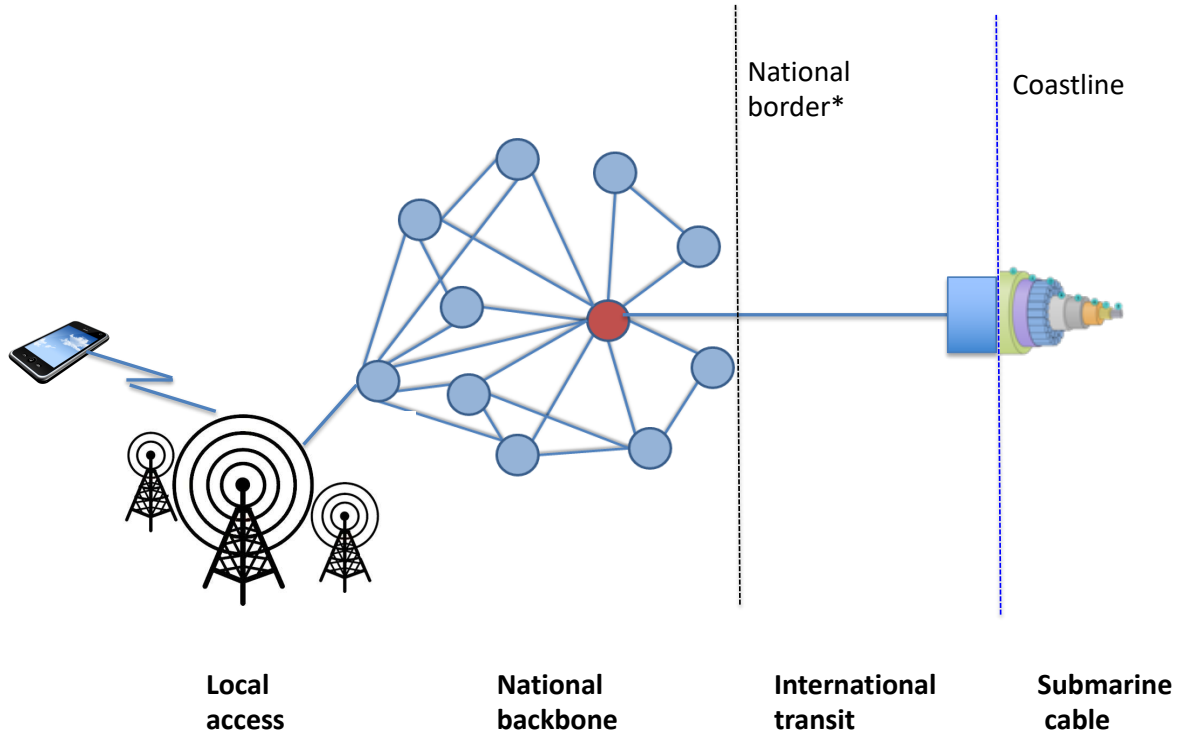
In such countries policy-makers will need to focus their attention on those components of Internet access that are unusually expensive in their country and adopt policies that help to reduce those costs (e.g. through public investment, targeted subsidies or tax breaks) so as to improve Internet affordability.

1.3 Methodology

The costs of Internet access can be broken down into four components as shown in Figure 2:

- **Local access**: this can be provided through a fixed or WiFi connection to the national network, but in the majority of cases in developing countries it will be provided over a mobile network.
- **National backhaul**: the link from the mobile access network to the international gateway or (for landlocked countries) to the national border.
- **International transit**: for landlocked countries (and occasionally for others) there is a need to purchase capacity on another country's network to reach the cable landing station.
- **Submarine cable**: investment in or lease of capacity from whichever of the submarine cables that lands in the country.

Figure 2: Main cost components of Internet access



* The national border (and international transit) applies only to landlocked countries; for other countries the national maritime border is located 12km beyond the coastline.

The key thing about almost all of these costs, and especially the last three categories, is that they are predominantly fixed costs: there is a sizeable up-front investment and a relatively small cost for incremental capacity. As a result, there are substantial economies of scale to be had which means that small developing countries will inevitably suffer from higher unit costs and higher end-user prices.

The extent to which scale economies are reduced and unit costs increased depends on the demographic and geographic characteristics of the country. Countries with a small population will suffer significantly higher costs as they have the least opportunity to realise economies of scale, and countries where the population is spread over a large land area (i.e. a low population density) will suffer from increased fixed costs of network coverage and higher unit costs. Furthermore, landlocked countries incur additional costs because of the need to lease international transit capacity and island nations[5] suffer higher costs because they need to deploy submarine cables for domestic as well as international services.

[5] The same issue may affect nations with especially long coastlines (e.g. Brazil, Mozambique) where submarine cables are deployed to connect coastal towns.

The extent of these exogenous cost inequalities can only be estimated through the construction of detailed network cost models. Constructing separate models for each of the four network components and for each benchmark country is beyond the scope of the present exercise, but an approximation was achieved by examining the results a series of regulatory cost models from a range of developing countries[6]. From the results of these models under various input parameters a simplified cost-volume relationship was determined for each of the four major network components. This approach works on the basis of two main assumptions:

- A straight-line function, of the form **ax + b**, is assumed where "**b**" is the fixed cost and "**a**" the incremental costs associated with an increase in volume of "**x**". Such a function is clearly a simplification of reality because costs are incurred in different increments for each relevant network asset, and the cost of additional increments may itself reduce with scale (e.g. volume discounts from suppliers). However, the error margin is likely to be tolerable so long as the benchmark countries are comparably sized to those from which the cost model data has been obtained. With the possible exceptions of Samoa (low end) and Brazil (high end) the benchmark countries fulfil this requirement.
- The two volume variables "**x**" are related to the mobile subscriber base and the land area of the country. The use of mobile subscribers as a cost-driver is clearly inaccurate in the real world, since there may be substantial differences in usage-per-subscriber, both within and between countries. However, normalizing these differences has the advantage of focusing on exogenous cost differences – those that cannot be removed simply by increasing Internet usage per subscriber. The use of land area as a driver of costs is reasonable so long as, within the benchmark countries, a similar proportion of land is within the network coverage area. With the possible exceptions of Namibia (low end) and Maldives (high end) the benchmark countries fulfil this requirement.

1.4 Cost-volume relationships

Separate cost-volume relationships were derived for each of the four main components of Internet access costs. They are as shown in Figure 3.

[6] These are based on actual proprietary cost models developed by the author working in the following countries: Bangladesh, Belize, Lesotho, Liberia, Malawi, Mozambique, Tanzania and Tonga.

Figure 3: Simplified cost-volume relationships for the main cost components of Internet access

In a typical developing country with 1m population
per submarine cable

Cost component	USD '000s p.a.	Cost-volume relationship*
Annual capital charge for submarine cable	3000	1.25
Opex related to submarine cable	1500	1.25
Annual capital charge for cable landing site and equipment	150	1.25
Locally incurred opex	800	1.8
TOTAL annual costs	**5450**	**1.33**

* Cost-volume relationship represents the proportional increase in costs for a doubling of volumes.

International transit capacity costs

In a typical developing country with 1m population and per 1000km transit links
per transit link

Cost component	USD '000s p.a.	Cost-volume relationship*	Cost-distance relationship**
Leased capacity	300	1.25	1.75
TOTAL annual costs	**300**	**1.25**	**1.75**

* Cost-volume relationship represents the proportional increase in costs for a doubling of volumes.
** Cost-distance relationship represents the proportional increase in costs for a doubling of transmission length.

National internet backhaul capacity costs

In a typical developing country with 1m population and 1000km of backbone network
per backbone network

Cost component	USD '000s p.a.	Cost-volume relationship*	Cost-distance relationship**
Transmission equipment	500	1.25	1
Network nodes	360	1.25	1.5
Sites	40	1.25	1.5
Passive transmission (trench, duct, pole etc)	1500	1	2
TOTAL annual costs	**2400**	**1.09**	**1.47**

* Cost-volume relationship represents the proportional increase in costs for a doubling of volumes.
** Cost-distance relationship represents the proportional increase in costs for a doubling of transmission length.

Mobile broadband access costs

In a typical developing country with 1m subscribers per operator and 100,000 km² network coverage
per mobile network operator

Cost component	USD '000s p.a.	Cost-volume relationship*	Cost-area relationship**
Cell sites	12500	1.2	1.4
Radio equipment	8400	1.5	1
Service equipment	6600	1.4	1
TOTAL annual costs	**27500**	**1.34**	**1.12**

* Cost-volume relationship represents the proportional increase in costs for a doubling of volumes.
** Cost-area relationship represents the proportional increase in costs for a doubling of the geographical area of the country.

All of the component costs are related to the traffic level on the network, which is driven by subscriber numbers (assuming equal Internet usage per subscriber). Some of the components also have a distance dependency within them, based on the length of transmission links, which is driven by the land area of the country or the transit distance to the nearest submarine cable landing station.

1.5 Benchmark countries

The countries selected for analysis are shown in Figure 4.

Figure 4: Benchmark countries chosen for cost analysis

Country	Type of country illustrated	GNI per capita, Atlas method (current US$)	Population ('000s)	Area ('000s km^2)	Population density (per km^2)	Mobile subscribers ('000s)
Bolivia	Large landlocked country with low population density	3130	11051	1098	10	10106
Zambia	Large landlocked country with low population density	1300	17094	752	23	12017
Zimbabwe	Large landlocked country with low population density	910	16529	391	42	12878
Lao	Large landlocked country with low population density	2270	6858	230	30	3958
Ethiopia	Large landlocked country with high population density	740	104957	1000	105	51224
Uganda	Large landlocked country with high population density	600	42862	200	214	22838
Brazil	Large coastal or island country with low population density	8580	209288	8515	25	244067
Namibia	Large coastal or island country with low population density	4600	2534	824	3	2659
Peru	Large coastal or island country with low population density	5970	32165	1280	25	36933
Kenya	Large coastal or island country with high population density	1440	49700	569	87	38982
Nigeria	Large coastal or island country with high population density	2080	190886	911	210	154342
Thailand	Large coastal or island country with high population density	5960	69037	511	135	119669
Malawi	Small landlocked country with high population density	320	18622	94	198	7178
Burundi	Small landlocked country with high population density	290	10864	26	423	5357
Lesotho	Small landlocked country with low population density	1280	2234	30	73	2282
Swaziland	Small landlocked country with low population density	2960	1367	17	79	995
Bhutan	Small landlocked country with low population density	2720	807	38	21	698
Samoa	Island archipelago with low population density	4100	196	3	69	125
Fiji	Island archipelago with low population density	4970	905	18	49	1044
Philippines	Island archipelago with high population density	3660	104918	298	352	113000
Maldives	Island archipelago with high population density	9570	444	0	1480	812
Liberia	Small coastal or island country with low population density	380	4731	111	43	3117
Timor Leste	Small coastal or island country with low population density	1790	1296	15	87	1492
Sri Lanka	Small coastal or island country with high population density	3840	21444	66	327	25797
Sierre Leone	Small coastal or island country with high population density	510	7557	72	105	6279

Data on submarine cables from Telegeography - Submarine Cable World Map, 2018
All other data from World Bank Databank (2017, except mobile subscribers 2016).

These countries were chosen in order to include:

- at least two countries in each of the country types based on the identified significant cost drivers for Internet access. The resultant country types are:
    - Large[7] landlocked country with low[8] population density
    - Large landlocked country with high population density
    - Large coastal or island country with low population density
    - Large coastal or island country with high population density
    - Small landlocked country with low population density
    - Small landlocked country with high population density
    - Small coastal or island country with low population density
    - Small coastal or island country with high population density
    - Island archipelago with low population density

[7] Large countries are considered to be at least 200,000km^2 in land area.
[8] Low population density is defined as below 100 people per km^2.

  - Island archipelago with high population density.

- a representative sample of Low Income countries (GNI per capita < US$995), Lower-Middle Income countries (GNI per capita US$996-3895) and Upper-Middle Income countries (GNI per capita US$3896-12,055) based on the World Bank's country categorization for 2018.

For each of these countries a number of additional assumptions have been made in order to assess the costs of each of the four main network components of Internet access. These assumptions are shown in Figure 5.

Figure 5: Network assumptions for the benchmark countries

Country	Number of:					
	Mobile network operators	International submarine cables	National submarine cables	National backbone networks	International transit links	Average distance to CLS (for landlocked countries) - km
Bolivia	3	0	0	1	4	2000
Zambia	3	0	0	1	4	2000
Zimbabwe	3	0	0	1	2	1000
Lao	4	0	0	1	2	500
Ethiopia	1	0	0	1	4	1000
Uganda	5	0	0	1	4	1000
Brazil	6	13	13	1	0	0
Namibia	2	2	0	1	0	0
Peru	4	11	0	1	0	0
Kenya	3	4	0	1	0	0
Nigeria	5	7	0	1	0	0
Thailand	4	11	0	1	0	0
Malawi	2	0	0	1	2	1500
Burundi	2	0	0	1	2	1500
Lesotho	2	0	0	1	2	500
Swaziland	1	0	0	1	2	500
Bhutan	3	0	0	1	2	1000
Samoa	2	1	1	1	0	0
Fiji	2	3	1	1	0	0
Philippines	2	13	14	1	0	0
Maldives	2	2	11	1	0	0
Liberia	3	1	0	1	0	0
Timor Leste	3	1	0	1	0	0
Sri Lanka	2	8	0	1	0	0
Sierre Leone	2	1	0	1	0	0

Sources: Author assumptions (using data from Wikipedia, Telegeography)

1.6 Key results in the benchmark countries

The purpose of the cost modelling exercise was to determine the extent to which the costs of Internet access vary between different country types and to understand the reasons for those variations. Figure 6 shows the estimated average cost of Internet access in each of the different country types.

Figure 6: Estimated average annual cost of Internet access in different country types

Country type	Examples	Cost of Internet access in USD per subscriber p.a.
Large landlocked country with low population density	Bolivia, Laos, Zambia, Zimbabwe	15.25
Large landlocked country with high population density	Ethiopia, Uganda	5.38
Large coastal or island country with low population density	Brazil, Namibia, Peru	19.68
Large coastal or island country with high population density	Nigeria, Thailand	7.66
Small landlocked country with high population density	Burundi, Malawi	6.78
Small landlocked country with low population density	Bhutan, Lesotho, Swaziland	29.15
Island archipelago with low population density	Fiji, Samoa	54.14
Island archipelago with high population density	Philippines, Maldives	35.20
Small coastal or island country with low population density	Liberia, Timor Leste	23.05
Small coastal or island country with high population density	Sierre Leone, Sri Lanka	11.13
Average across all categories		**20.74**

Figure 6 demonstrates that there are substantially different costs in different types of country based on geographic and demographic factors that are outside of the control of operators, regulators and policy makers. Although the average cost is $20 per subscriber per annum, it varies between $7 and $54, roughly a range of ±200%.

What causes this wide variation? To address this issue, we need to consider the major components of Internet costs. Figure 7 identifies the breakdown of total Internet access costs into the four main components identified earlier.

Figure 7: Breakdown of Internet access costs by cost components in different country types

Country type	Examples	International internet capacity	International transit capacity	National internet backhaul capacity	Mobile broadband access	TOTAL
Large landlocked country with low population density	Bolivia, Laos, Zambia, Zimbabwe	22%	1%	2%	75%	100%
Large landlocked country with high population density	Ethiopia, Uganda	34%	0%	2%	64%	100%
Large coastal or island country with low population density	Brazil, Namibia, Peru	29%	0%	5%	66%	100%
Large coastal or island country with high population density	Nigeria, Thailand	33%	0%	1%	66%	100%
Small landlocked country with high population density	Burundi, Malawi	31%	0%	3%	66%	100%
Small landlocked country with low population density	Bhutan, Lesotho, Swaziland	30%	1%	4%	65%	100%
Island archipelago with low population density	Fiji, Samoa	24%	0%	8%	68%	100%
Island archipelago with high population density	Philippines, Maldives	36%	0%	27%	37%	100%
Small coastal or island country with low population density	Liberia, Timor Leste	13%	0%	3%	84%	100%
Small coastal or island country with high population density	Sierre Leone, Sri Lanka	33%	0%	2%	66%	100%
Average across all categories		**29%**	**0%**	**6%**	**66%**	**100%**

In virtually all cases the major cost component is the mobile network. And this cost is increasing: as data traffic growth outpaces voice, so the vast majority of mobile network costs are now caused by data services. Typically, 75% of the total costs of mobile networks may now be allocated to data services[9]. Furthermore, while there is a significant fixed cost of providing mobile network coverage in a country (especially in large countries with low population density) the major cost driver in most areas of most countries is now the data traffic volume.

The second most significant cost component is the submarine cable that provides access to the world's Internet superhighway. The profile of these costs is different from those of the

[9] Based on proprietary cost models developed by the author for national regulatory authorities.

mobile network – the upfront investment is higher and the economies of scale are greater. In a typical submarine cable each unit of capacity purchased costs 25% of the previous unit. This means that countries that can generate high traffic volumes (e.g. because of high population, high broadband take-up or the implementation of policies and practices that stimulate demand) will benefit from lower unit costs. On the other hand, small countries inevitably spend much more per capita on submarine cable access than do highly populated countries.

In comparison with mobile broadband access and submarine cable capacity, the last two elements (international transit capacity and national backbone capacity) generally represent a much lower proportion of total Internet access costs. International transit is only relevant to landlocked countries and, even for those with low population density, this accounts for no more than 1% of total internet access costs[10]. National backhaul costs are generally more significant, amounting to 6% of total Internet costs on average, and can be quite substantial for larger countries with extensive national backbone networks and/or countries that have to deploy submarine cables as part of the national backbone network (e.g. island archipelagos).

1.7 Can cost differences be overcome?

The analysis presented above demonstrates that some facets of country geography and demography affect the costs of Internet access. However, for each of the benchmark countries the impact of these factors is different because they are all of different land area, population and teledensity. The small size of the sample (28 countries divided into 10 country types) means that observed differences in Internet access costs may just reflect differences between the benchmark countries rather than exogenous cost differences between the country types.

To correct for such a potential sample bias, we have produced a normalized cost analysis. This analysis is based on notional countries, one for each of the country types, that are each based on the average of the benchmark set in terms of land area (large and small), population density (low and high) and mobile teledensity. All the other assumptions shown in Figure 5 have also been averaged.

Using this approach, we have been able to estimate the irreducible cost differentials between the various country types. The results are shown in Figure 8.

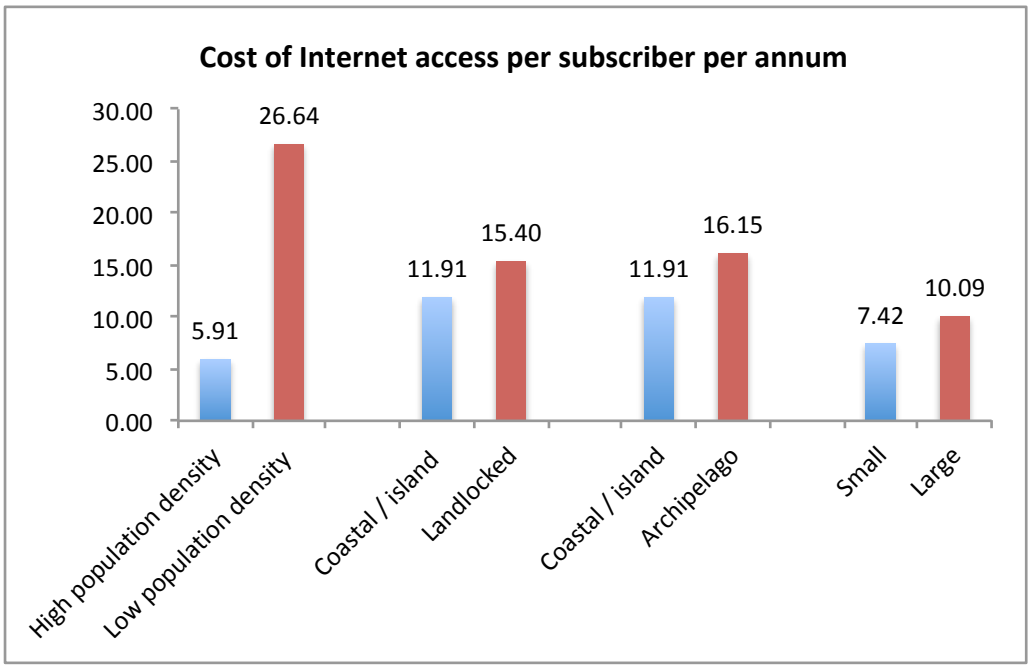
It can be seen that, all else being equal, Internet access is more expensive in:

- Countries with low population density – scale economies are far lower than in high-density countries of the same land area because the fixed costs of providing internet access are shared between fewer customers.

[10] This assumes that the prices for international transit reflect the costs and are not inflated to provide excessive profit margins to the neighbouring country.

- Landlocked countries – the need for international transit links to the submarine cable landing station adds a relatively small additional cost compared to a coastal country that has its own landing station.
- Island archpelagos – the need for national submarine cable links between islands adds a relatively small additional cost compared to a mainland nation.
- Large countries – scale economies are lower than in small countries with equal population because the national backhaul network is more expansive and costlier.

Figure 8: Variation in Internet access costs by country type



Taken together, these four factors explain the cost differences witnessed between the 28 benchmark countries shown in Figure 1. It is intrinsically more expensive to deploy Internet access in some countries than in others. The smallest, least-populated and island archipelago nations have a distinct cost disadvantage. There is nothing that policy-makers can do to change this immutable fact caused by the economics of geography and demography.

There are, however, steps that policy makers can take to reduce the impact of these exogenous cost differences. For example, in the Pacific Island nations the World Bank has offered interest-free loans for accessing submarine cables[11], thus greatly reducing the impact of this critical cost component. Similar investment loans from the Chinese government have reduced the costs of national backbone networks in countries such as

[11] See: http://documents.worldbank.org/curated/en/951531468096566273/Pacific-Islands-Regional-Connectivity-Project

Malawi[12] and Tanzania[13], and across Southern Africa, where many poor countries are also landlocked, a regional initiative has been taken to reduce the price of international transit and avoid exploitation by neighbouring countries that control the essential facilities of transit and access to the cable landing station[14].

A more broadly applicable approach is to implement policies that stimulate demand, possibly going as far as explicit subsidies on retail Internet access, both for the infrastructure access and for end-user devices. Lower end-user prices provide the best way to stimulate demand. As volumes grow so unit costs will fall, and further price cuts will be enabled. This is a strategy that should be adopted by all developing countries as they seek to improve Internet affordability.

Clearly there is more work to do, and smaller and more isolated countries will always be at a disadvantage – however good they are at demand stimulation they will never achieve the scale economies available elsewhere. The Internet in many countries remains expensive relative to income. This may mean that some high-capacity applications – such as interactive gaming and video – may not be affordable, but user adaptation, innovation and policy initiatives such e-Government, e-Health and the local caching of popular content, mean that many applications are already available and affordable to many users. This in turn fuels demand, lowers unit costs, and results in prices that become ever more affordable. Positive feedback indeed!

***David Rogerson**,*

Director, Incyte Consulting Ltd

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[12] See: http://www.ict.gov.mw/index.php/projects/national-fiber-backbone
[13] See: http://www.biztechafrica.com/article/good-progress-tanzanian-ict-backbone/2331/
[14] See: https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/IIC_Africa_Final-en.pdf