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## Infrastructure Gap in South Asia: Inequality of Access to Infrastructure Services

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# Infrastructure Gap in South Asia

## Inequality of Access to Infrastructure Services

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## Abstract

The South Asia region is home to the largest pool of individuals living under the poverty line, coupled with a fast-growing population. The importance of access to basic infrastructure services on welfare and the quality of life is clear. Yet the South Asia region's rates of access to infrastructure (sanitation, electricity, telecom, and transport) are closer to those of Sub-Saharan Africa, the one exception being water, where the South Asia region is comparable to East Asia and the Pacific and Latin America and the Caribbean. The challenge of increasing access to these services across the South Asia region is compounded by the unequal distribution of existing access for households. This study improves understanding of this inequality by evaluating access across the region's physical (location), poverty, and

income considerations. The paper also analyzes inequality of access across time, that is, across generations. It finds that while the regressivity of infrastructure services is clearly present in South Asia, the story that emerges is heterogeneous and complex. There is no simple explanation for these inequalities, although certainly geography matters, some household characteristics matter (like living in a rural area with a head of household who lacks education), and policy intent matters. If a poorer country or a poorer state can have better access to a given infrastructure service than in a richer country or a richer state, then there is hope that policy makers can adopt measures that will improve access in a manner in which prosperity is more widely shared.

This paper is a product of the Sustainable Development Department, South Asia Region. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The authors may be contacted at [landres@worldbank.org](mailto:landres@worldbank.org), [dbiller@worldbank.org](mailto:dbiller@worldbank.org), and [mdappe@worldbank.org](mailto:mdappe@worldbank.org).

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# **Infrastructure Gap in South Asia: Inequality of Access to Infrastructure Services<sup>1</sup>**

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**JEL Classification:** D6, O1, O18, O53, R10

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## 1. Introduction

**The South Asia Region (SAR) is home to the largest pool of individuals living under the poverty line, coupled with some of the fastest demographic growth rates of any region in the world.** Between 1990 and 2005, the number of people living on less than \$1.25 a day in South Asia decreased by only 18 percent, while the population grew by 42 percent.<sup>2</sup> At the same time, over the past two decades, structural change has been slow, *with urbanization (around 31 percent) lower than in any other developing region*, despite economic growth rates that have exceeded most other regions. While the burst of economic growth has generated additional revenue and increased fiscal space to shift more funds to infrastructure, it has also put immense pressure on demands for infrastructure.

**The challenges on the infrastructure front for SAR are monumental.** For the past two decades, SAR and East Asia and the Pacific (EAP) have enjoyed similar growth rates, yet SAR lags significantly behind both EAP and Latin America and the Caribbean (LAC) when it comes to access to infrastructure services – with certain areas featuring access rates comparable only to Sub-Saharan Africa (SSA). For example, Afghanistan, Nepal, and Bangladesh have access rates that resemble the average Sub-Saharan country, while Sri Lanka and the Maldives are more similar to Latin American countries in terms of average rates of infrastructure services. At the same time, SAR features significant heterogeneities within and among countries in terms of access to infrastructure services. Districts with very low access to infrastructure can be found in rich Indian states and vice versa: some districts in poor Indian states fare better in terms of infrastructure than districts in rich states. Finally, heterogeneity across sectors is also found within districts. For example, high access rates of electricity coexist in the same district with low access rates to sanitation or other infrastructure services.

**The importance of access to basic infrastructure services like clean water, adequate sanitation, and electricity on welfare and the quality of life is well established.** Clean water and power services bring votes in democratic political processes, and individuals usually display high willingness to pay (WTP) as households benefit directly. These services are also associated with key health and environmental externalities. As a direct benefit to neighbors, individuals may have a lower WTP for adequate sanitation in their households, but the health and environmental externalities associated with it are even more important. There is a growing literature associating phone access to poverty reduction, and the rapid expansion of mobile access – largely driven by the private sector – reflects the fact that agglomeration effects and connectivity are important for the poor. In addition, cooking gas (LPG) as a source of fuel plays a vital role in diminishing indoor air pollution. Moreover, differences in access to infrastructure services could be a bottleneck not only in improving the well-being of current family members but also in breaking inter-generational transmission of poverty.

**It is commonly asserted that the poor have less access to infrastructure than the rich just like in the case of private assets.** In effect, a non-regressive access to infrastructure services would mean no correlation between actual access and different poverty related measures (such as households below poverty lines, and certain income and consumption levels). Whereas this may be desirable theoretically – especially for infrastructures with high public good characteristics – it is virtually impossible to achieve anywhere in the world. For example, location matters, and the choice between infrastructure access to all regardless of where individual households are located and quality access to where most households

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<sup>2</sup> The proportion of people living on less than \$1.25 a day decreased from 54 percent to 31 percent (a 42 percent decrease), between 1990 and 2010, mainly due to the increase in population.

are located is a real policy challenge illustrated in its extreme case. While literature on the topic is scant, it is clear that not all countries fare the same in their infrastructure service provision and South Asian countries are not different. Yet, are there countries in South Asia that fare better with respect to providing infrastructure access to their poor? Are there infrastructure sectors that tend to be more regressive than others? Does geography matter? What is happening with access to infrastructure services in South Asian households? These are a few of the questions that we explore.

**In this paper we present three different views about the distribution of infrastructure services for selected countries in South Asia.**<sup>3</sup> The paper is organized as follows. We begin with the standard view of access to infrastructure services, a conceptual framework and the relation between access deficit and the large infrastructure gap in South Asia. We then discuss inequality of access to infrastructure services across South Asia's spaces – namely physical space, poverty space, and income space. Next we turn to inequality of access across time, focusing on the impact of the infrastructure gap across South Asian generations. Finally, we present policy suggestions on how to target the poor while focusing on correcting market failures connected to infrastructure, underscoring the importance of avoiding rent-seeking opportunities.<sup>4</sup>

**Our conclusion is that while the regressivity of infrastructure services is clearly present in South Asia, the story that emerges is heterogeneous and complex.** Countries with higher per capita income (like the Maldives and Sri Lanka) enjoy better access to infrastructure services both spatially and income wise, even though conflict areas are clearly worse off. Among sectors in SAR countries, some, such as water, tend to be more equally distributed than others, such as sanitation, energy, and phones – with the widespread use of firewood for cooking, especially among the poor, somewhat surprising. Moreover, within SAR countries, some states and districts have better access than others. There is no simple explanation for these inequalities, although certainly geography matters, some household characteristics matter (like living in a rural area with a head of household who lacks education), and policy intent matters. If a poorer country or a poorer state can have better access to a given infrastructure service than in a richer country or a richer state, then there is hope that policy makers can adopt measures that will improve access in a manner that prosperity is more widely shared.

## 2. Access to infrastructure services and the Infrastructure Gap in South Asia

**Consistent estimates of investment requirements across SAR are a pre-requisite for developing a sound menu of policy and financial options to close the infrastructure gap.** Most governments in SAR have some estimates of the investments required to reach certain targets such as 24/7 electricity supply and the Millennium Development Goals in water and sanitation. However, those estimates are not consistent across the region. For that reason Andres et al. (2013) have developed different methodologies for different sectors to have consistent estimates of physical investment needs and their costs across the region.

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<sup>3</sup> The selection of countries and infrastructures were based largely on data availability, data consistency across databases and consistencies within databases.

<sup>4</sup> Additional information on methodology, models, background papers, stock taking reviews, and data used can be found in the Infrastructure Needs Regional Study webpage: <http://go.worldbank.org/ZRTCA2AKR0>

**SAR needs to invest an estimated US\$ 1.7 trillion to US\$ 2.5 trillion in infrastructure until 2020.**<sup>5</sup> These amounts are equivalent to US\$ 1.4 trillion to US\$ 2.1 trillion at 2010 prices. Going forward, a mix of investing in infrastructure stock and implementing supportive reforms will allow SAR to close its infrastructure gap. In GDP terms, if investments are spread evenly over the years until 2020, SAR needs to invest between 6.6 and 9.9 percent of 2010 GDP per year – an increase of up to 3 percentage points compared with the 6.9 percent of GDP invested in infrastructure by SAR countries in 2009.<sup>6</sup>

## 2.1 Regional Benchmarking

**SAR has a large infrastructure gap compared with other regions.** Its access to infrastructure services closely resembles SSA, even though its economic growth is second only to EAP (Table 1).

- **Electricity access:** In SAR only 71 percent of the population enjoys the benefits of electricity access, ahead of SSA at 35 percent, but way behind the rest of the regions at above 90 percent. According to businesses in South Asia, infrastructure is a major or severe hindrance to their growth, and electricity is the largest problem.
- **Improved sanitation access:** In this category, SAR (39 percent) is at the bottom with SSA (30 percent) – rates that are close to half the world average of 64 percent population access. Open defecation seems to be one of the most salient issues facing SAR, with 700 million people (i.e., 43 percent of the population) relying on it in 2010. This ranks South Asia as the region with the highest incidence of open defecation in the world.
- **Improved water access:** This is the only indicator where South Asia is about even with the rest of the world and EAP, averaging 90 percent population access. Yet the quality and quantity of improved water may be in question. Most of the access to water is through public stands; only 25 percent of the population has access to piped water and 24/7 water supply is a rare exception in South Asian cities.
- **Telecom access:** Communication among people who are not in close proximity is inefficient. In terms of telecom access (measured as fixed and mobile lines per 100 people), SAR and SSA rank at the bottom (72 and 54) with less than half the access found in ECA and LAC (157 and 125). This situation becomes even more dramatic given SAR's low level of urbanization.
- **Transport access:** This other form of connectivity is also poor – a problem that troubles much of the developing world. Using total road network per 1,000 people, SAR has 2.7 km—which is close to EAP (2.5 km), SSA (2.5 km), and MNA (2.8 km), but well below the world average (4.7 km), ECA (8 km), and North America (24 km). Furthermore, the transport infrastructure suffers from serious shortcomings (such as lack of intraregional connectivity between the national road networks, unrealized potential for rail and inland water freight transport, and inadequate road and rail connectivity of ports with hinterlands). These limitations turn transport infrastructure into a hindrance for regional and international trade, as investment climate surveys indicate.

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<sup>5</sup> The US\$ 1.7 to US\$ 2.5 trillion are at current prices, and they are equivalent to US\$ 1.4 to US\$ 2.1 trillion at 2010 prices.

<sup>6</sup> These percentages are based on the investment requirements at 2010 prices.

**Table 1: SAR Lagging Behind All But SSA in Access to Infrastructure Services**

	Avg GDP Growth (2000-2012)	Urbanization Rate (2012)	Telecom Access (per 100 people) (2011) <sup>1</sup>	Electricity Access (% of pop.) (2010) <sup>2</sup>	Access to Improved Sanitation (% of pop.) (2011) <sup>3</sup>	Access to Improved Water (% of pop.) (2011) <sup>4</sup>
EAP	8.9	50	98	92	67	91
ECA	4.4	60	157	100	94	95
LAC	3.1	79	125	94	81	94
MNA	4.2	60	105	94	89	89
SAR	6.7	31	72	71	39	90
SSA	4.7	37	54	35	30	63
World	2.5	53	103	78	64	89

Source: World Development Indicators, except when noted otherwise.

Notes: 1. Telecom access is defined as the number of fixed and mobile lines; 2. World Energy Outlook 2010 by International Energy Association; 3. Improved sanitation is defined as connection to a public sewer, a septic system, pour-flush latrine, simple pit latrine, and ventilated improved pit latrine; 4. Improved water is defined as household connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection.

## 2.2 Within SAR Benchmarking<sup>7</sup>

**Sri Lanka and Maldives have the best access rates in the region.** As table 2 shows, more than 90 percent of their population has access to improved sanitation, which is better than in LAC at 81 percent. In terms of electrification, only Maldives (95 percent) and Sri Lanka (77 percent) are above the average rate for developing countries (76 percent).<sup>8,9</sup> On telecom, Sri Lanka and Maldives top the lists with 104 and 173 telephone lines per 100 people. This places Sri Lanka at the world average of 103 lines per 100 people and above EAP (98 lines per 100 people).

**Afghanistan, Nepal, and Bangladesh have the worst access rates in the region.** Nepal, with the lowest number of telephone lines per 100 people in SAR (47), is behind Afghanistan (54) – which matches SSA (54). For electrification, Afghanistan, not surprisingly, is the worst; a meager 30 percent of the population can rely on electricity powered lighting at night. Moreover, Afghanistan and Bangladesh (47 percent) are closer to the 35 percent found in SSA than to the 71 percent found in SAR. Total road network (km) per 1,000 people is also low in Nepal, Afghanistan, and Bangladesh. And only 29 percent of Afghanistan's roads, and 10 percent of Bangladesh's roads, are paved.

<sup>7</sup> It should be noted that in order to compare countries it is important to follow similar definitions of infrastructure services. Appendix A provides the definitions. Some countries may have higher than expected rates of access to a particular infrastructure, but this may come about because of the broad definition used for the particular infrastructure. The definitions are the basis of the household survey questionnaires commonly used and discussed in Appendix B.

<sup>8</sup> It should be noted that data sources are kept the same for consistency purposes when comparing countries. The Ceylon Electricity Board (CEB) estimates for example that over 90 percent of Sri Lankan households were electrified in 2011.

<sup>9</sup> World Energy Outlook, IEA:

<http://www.worldenergyoutlook.org/resources/energydevelopment/globalstatusofmodernenergyaccess/>



The exception is high average access to improved water in SAR, and not just in a few countries. Five out of the eight countries in SAR (i.e., Bhutan, India, Maldives, Pakistan, and Sri Lanka) have access rates to improved water of at least 90 percent, similar to the 94 percent rate found in LAC.

**Table 2: Big Range Among SAR Countries in Access to Infrastructure Services**

	Avg. GDP growth (2000-2012) <sup>1</sup>	Urbanization Rate (2012)	Telecom Access (per 100 people) (2011) <sup>2</sup>	Electricity Access (% of pop.) (2010) <sup>3</sup>	Access to Improved Sanitation (% of pop.) (2011) <sup>4</sup>	Access to Improved Water (% of pop.) (2011) <sup>5</sup>	Total Road Network (per 1000 people) <sup>6</sup>	% Paved Roads <sup>7,8</sup>
SAR	6.7	31	72	71	39	91	2.9	51
AFG	8.7	24	54	30	29	61	1.6	29
BGD	5.9	29	58	47	55	83	0.1	10
BTN	8.7	36	69	65	45	97	9.7	40
IND	7.1	32	75	75	35	92	3.5	50
MDV	7.0	42	173	95	98	99	0.3	100
NPL	4.0	17	47	47	35	88	0.8	54
PAK	4.4	37	65	65	47	91	1.5	72
LKA	5.5	15	104	77	91	93	5.5	81
Brazil	3.3	85	145	99	81	97	8.1	14
China	10.2	52	94	100	65	92	3.0	54

Source: World Development Indicators, except when noted otherwise.

Notes: 1. The average GDP growth for AFG is for the period 2002-2009; 2. Telecom access is defined as the number of fixed and mobile lines; 3. World Energy Outlook 2010 by International Energy Association, except BTN and MDV, which are based on authors' estimations; 4. Improved sanitation is defined as connection to a public sewer, a septic system, pour-flush latrine, simple pit latrine, and ventilated improved pit latrine; 5. Improved water is defined as household connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection; 6. Varying data years: 2005 (MDV), 2006 (AFG), 2008 (IND, NPL), 2010 (BGD, BTN, PAK, LKA, Brazil, China); 7. Varying data years: 2003 (LKA), 2005 (MDV), 2006 (AFG), 2008 (IND, NPL, China), 2010 (BGD, BTN, PAK, Brazil).

### 3. Inequality of Access to Infrastructure across South Asia's Space

So *who* has access to each type of infrastructure? We begin with a look at inequality of access across South Asia's space, weighing physical, poverty, and income considerations – an assessment that gives an encompassing picture of the infrastructure gap effects in the region but has never been done before. Where data is available,<sup>10</sup> we use four different analytical methods:

- **Gini coefficients on access to infrastructure services and households are estimated for a sample of administrative regions for each country for all countries of the region.** As with any Gini coefficient, zero expresses perfect equality, which theoretically could mean equal access to service or no access to service. A coefficient of one expresses maximal inequality among values (for example, only one district has access to infrastructure service). The goal is to have a country level measure of spatial inequality of infrastructure access adjusted by household spatial distribution.
- **Individual access to infrastructure service provision is analyzed for Sri Lanka, Afghanistan, and India.** This method provides a clearer picture of each sector in these countries and potential

<sup>10</sup> See appendix B for a discussion on the available data.

spillovers across sectors. The correlation of individual infrastructure service provision and the poverty rate (head counting) is estimated to understand the income regressivity of access to these services by sector.

- **Infrastructure indexes are constructed via two different methods for Sri Lanka and India.**<sup>11</sup> These methods, chosen to ensure result robustness include: (i) equal weights; and (ii) multicriteria decision-making approach assigning weights according to household level infrastructure service importance. The correlation of an infrastructure index and the poverty rate (head counting) is then presented visually. This analysis could be viewed as a proxy on how man-made capital important in public services is made available across space and income dimensions. The infrastructure index provides information about the overall service provision of key infrastructures across a country or group of countries. Yet, as a composite, it overshadows information on specific infrastructures. Infrastructure service delivery may vary owing to several factors – including characteristics inherent to the infrastructure (such as capital intensity), economic aspects (such as income), geography (such as proximity to source), and institutions (such as planning and implementation capacity, community cohesiveness).
- **Quintile analysis is done for Sri Lanka and Afghanistan.** The share of participation in total connections that each quintile of income has for each type of infrastructure is estimated where feasible, providing a very similar analysis to the classic Lorenz curve for income.<sup>12</sup>

### 3.1 Inequality of Access to Infrastructure: Physical Considerations

**How (un)equal is access to infrastructure among different administrative areas of a country (such as a district or a province)?** To analyze this, we estimate a Gini coefficient over the total of households that have access to a given type of infrastructure service. But differences in the distribution of the access could be determined by where the households are allocated in the country. So we estimate the Gini coefficient over the number of households of each administrative area. As the Gini can be a derivative from the Lorenz curve, we can subtract the Gini coefficient of population (H) from the Gini of connections (C). The intuition behind this estimation is to see if there are areas in a country that are not receiving a rate of access proportional to their population. Table 3 presents these measures of spatial inequality of infrastructure access adjusted by household spatial distribution for each country in the region. Access to a particular infrastructure service is spatially evenly distributed if its Gini coefficient is equal to the Gini coefficient of households – although this could also mean an equal absence of services.

**The snapshot of the spatial distribution of infrastructure services in South Asian countries is quite heterogeneous, with the Maldives having the lowest – and Afghanistan the highest – inequality of access to infrastructure services in the region (table 3).** These results are not surprising, especially in the case of Afghanistan, given its level of development, mountainous geography, and years of conflict. What is surprising, however, is Pakistan's adjusted Ginis, which show relatively low levels of spatial inequality. One possible explanation is the country's higher urbanization rate, with access to infrastructure services more skewed to its cities relative to other countries in the region.

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<sup>11</sup> See Appendix C for more details on how the indexes are constructed.

<sup>12</sup> The Lorenz curve plots the percentage of total income earned by various portions of the population when the population is ordered by the size of their incomes.

**Table 3: Tremendous Inequality of Access Across SAR's Physical Space**  
Gini Coefficients of Access to Infrastructure in South Asia

	AFG	BGD	NPL	LKA	IND	BTN	PAK	MDV
<b>Access Gini Coefficients ( C )</b>								
Improved Water	0.49	0.32	0.41	0.34	0.15	0.36	0.47	0.13
Improved Sanitation	.	0.30	0.43	0.33	0.38	0.55	0.47	0.24
Electricity	0.86	0.42	0.41	0.36	0.25	0.46	.	0.23
Cooking Gas	0.86	0.80	0.61	0.66	0.44	0.58	0.45	0.24
Phone	0.65	0.46	0.42	0.36	0.30	0.55	0.48	0.23
<b>Households Gini Coefficients ( H )</b>								
Population	0.37	0.31	0.37	0.32	0.10	0.36	0.45	0.23
<b>Access Gini Coefficients Adjusted by Household Distribution ( C - H )</b>								
Improved Water	0.12	0.01	0.04	0.01	0.06	0.00	0.02	-0.10
Improved Sanitation	.	-0.01	0.06	0.01	0.29	0.18	0.02	0.01
Electricity	0.49	0.11	0.04	0.04	0.15	0.10	.	0.00
Cooking Gas	0.50	0.49	0.24	0.33	0.35	0.22	0.00	0.01
Phone	0.28	0.15	0.05	0.03	0.20	0.19	0.03	0.00

Source: Authors' calculations based on surveys presented in Table 1 in Appendix B.

Note: The Gini coefficients are estimated over a sample of administrative subdivisions selected on each country.

**In terms of infrastructure service, the picture is also heterogeneous, with cooking gas (LPG) the most unequally distributed in spatial terms.** Given that cooking gas is mainly distributed by bottles, the high spatial inequality likely reflects LPG's reliance on transport connectivity and its capital intensive nature. The alternative to LPG becomes biomass. The heavy use of biomass for cooking rather than the cleaner LPG implies an intergenerational and intra gender trade-off since the significant pollution risks via indoor air contamination affect mostly children and women.

**Improved water is arguably the infrastructure that is most equally distributed in spatial terms** – which is important in terms of welfare impacts given that no one can survive without it, and in geographic terms since proximity to water sources is fundamental particularly in less developed countries.<sup>13</sup> The other sectors – improved sanitation, electricity, and phones – have adjusted spatial Ginis indicating less equality. Households, appropriately or not, generally solve their own sanitation needs, so the incentives to invest in adequate technologies are more limited than in the case of water. Lack of appropriate sanitation or lack of adequate sewage treatment becomes more of a locality problem, that is, a local public bad. This is in part implicit in the definition of unimproved versus improved sanitation.<sup>14</sup> Like water, electricity is a direct benefit to the household as opposed to sanitation. One would expect that households are willing to pay more for power but adequate electricity services can be costly.

**These sectoral results are influenced by the broad definitions used for improved water, sanitation, and electricity – which aggregate disparate type of services.** The aggregation “penalizes” countries, provinces, and districts with good access to grid electricity because it incorporates other forms of service provision. For example, Sri Lanka's adjusted spatial Gini in electricity is low, reflecting the high connection to the grid across the island (Biller and Nabi, 2013). Pakistan's adjusted spatial Gini is also

<sup>13</sup> Improved water is a noticeable outlier in the Maldives which may be explained by small atolls having more access in relative terms because of the inclusion of rain water in improved water.

<sup>14</sup> An improved sanitation facility is defined as one that hygienically separates human excreta from human contact (see Appendix A).

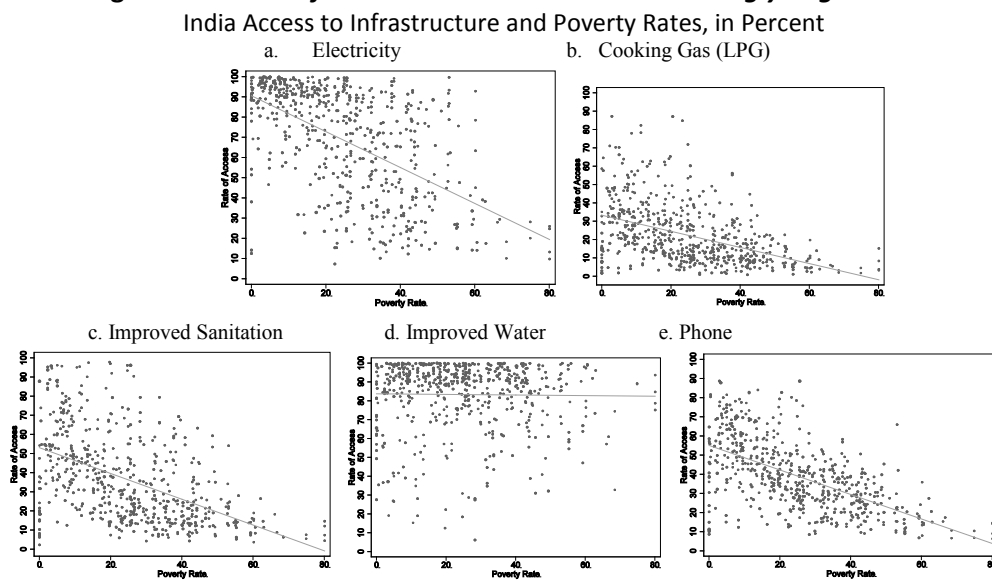
low, but so is its grid connectivity. The adjusted spatial Gini of phones is also variable across countries probably reflecting topography and connectivity; that is, geography matters. This is true even for cooking gas as cheaper alternatives like firewood are generally not available in an atoll like the Maldives. The aggregated numbers provide a broad subsectoral picture of service locations. Further analysis on poverty provides a more complete picture of regressivity in infrastructure service provision.

### 3.2 Inequality of Access to Infrastructure: Poverty Considerations

**Another way to analyze spatial inequalities is by analyzing how pockets of poverty fit into the picture – in effect, introducing a socio-economic variable.** Here, we correlate the district poverty rate (percentage of people of each district that live under the poverty line) with the district rate of access to infrastructure (percentage of households that have infrastructure in each district) in three countries. We assume that a country with a higher poverty rate will have worse access to infrastructure services than a country with a lower one. But how strong is that link? The results here show that it varies.

**India shows strong regressivity of infrastructure service access except in water services (figure 1) while Sri Lanka shows a relatively weak regressivity of infrastructure service access (figure 2).** In India, the water exception is similar to that in the other countries. In Sri Lanka, the exceptions to this trend are cooking gas and phone, which show a much stronger link. The overall low level of regressivity is a stark contrast to both Afghanistan and India, which show much stronger relationships even for the most basic infrastructures.

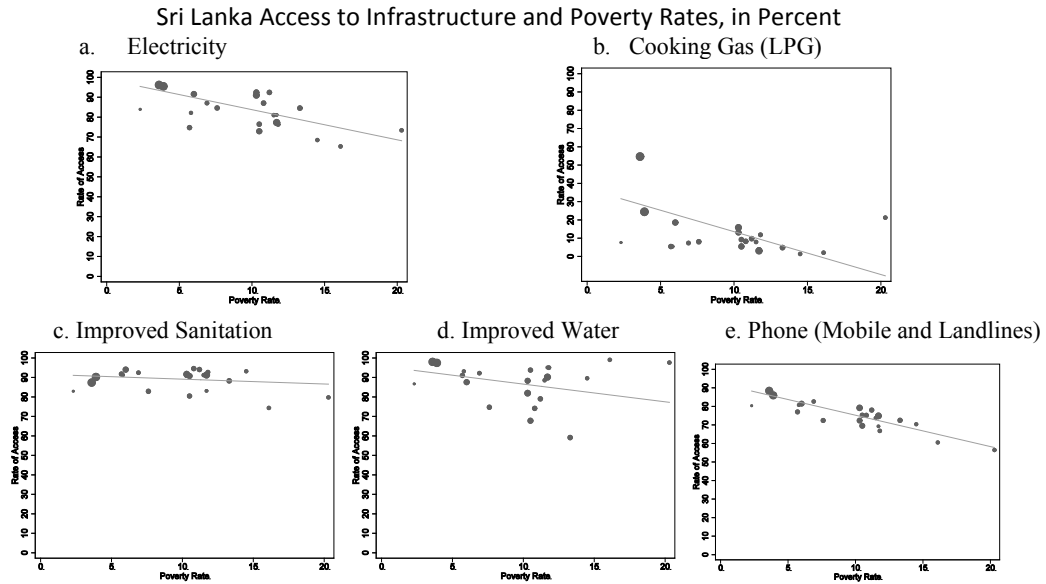
**Figure 1: India's Infrastructure Services Access is Strongly Regressive**



Source: Authors' calculations based in infrastructure access from India DHLS-3 and poverty rates from Debroy and Bhandari (2003).

Note: The size of each point is based on the population size. The coefficients associated with the scatter plots are -0.89 for electricity, -0.44 for cooking gas, -0.67 for improved sanitation, -0.02 for improved water, and -0.64 for phone. All (but improved water) these coefficients are significant at 99% confidence.

**Figure 2: Sri Lanka's Infrastructure Services Access is Only Weakly Regressive**



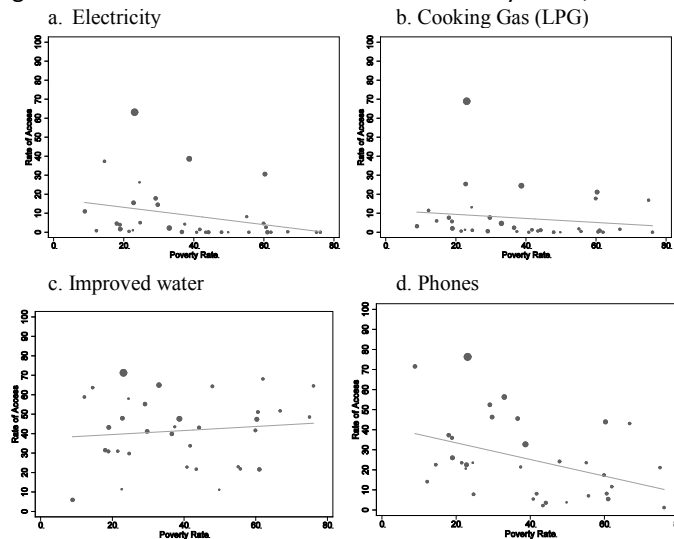
Source: Authors' calculations based in Sri Lanka HIES 2010.

Note: The size of each point is based on the population size. The coefficients associated with the scatter plots are: -1.51 for electricity, -2.34 for cooking gas, -0.25 for improved sanitation, -0.9 for improved water, and for phone -1.69. All these coefficients (but improve sanitation and improved water) are significant at 99% confidence.

**Afghanistan shows a relatively strong regressivity, except in water and in its capital – Kabul also has one of the lower poverty rates in the country (figure 3).** While most access to infrastructure services in the country is regressive in income, water stands out as non-regressive even when the adjusted spatial Gini is much higher than in the other countries – illustrating the difference between a physical spatial measure and one involving socio-economic parameters. Yet, while sanitation appears more regressive in income than in other countries, cooking gas seems less regressive than in other South Asian countries.

**Figure 3: Afghanistan's Infrastructure Services Access is Regressive**

Afghanistan Access to Infrastructure and Poverty Rates, in Percent



Source: Authors' calculations based in Afghanistan NVRA 2008.

Note: The size of each point is based on the population size. The coefficients associated with the scatter plots are -0.03 for improved water, -0.39 for electricity, -0.36 for cooking gas, and -0.66 for phone. The coefficients for electricity and phone are significant at 90% confidence.

### 3.3 Inequality of Access to Infrastructure: Physical and Poverty Considerations

**Yet another way to analyze spatial inequalities is by bringing poverty data together with access data.** We do this for India and Sri Lanka. Using the infrastructure indexes described in Appendix C, maps overlaying the location of infrastructure services and poverty can be generated. The indexes encompass only the basic infrastructure services that have the highest impact on welfare (such as water, sanitation, and electricity).<sup>15</sup> Andres et al. (2013) presented these maps using a multicriteria decision-making approach to assign weights according to household level infrastructure service importance for India and Sri Lanka. Colors indicate access to infrastructure services; that is, gold and green represent better access. Height provides a relative poverty measure (a poverty rate); that is, the number of poor individuals in each district /total headcount of each district.

**Leading regions generally mean better access but lagging regions do not necessarily mean worse access.** As expected, the mountains of India are located in the lagging states (those with a higher poverty level) and the plains in the leading states (those with a lower poverty level). There is a clear dominance of reds and browns in lagging states as well, reflecting that states where poverty rates are higher have less access to basic infrastructure services. This is intuitively expected. The curious exception is the northeast area bordering Bangladesh, Bhutan, China, and Myanmar, where there is more green and gold.

**The positive exception found in northeast India is more prevalent generally in Sri Lanka.** Using the same technique, access to basic infrastructures seems to be more inclusive in Sri Lanka. Access is widely spread, and the quality of these services in the country is known to be generally good. It is clear that the leading region – the Western Province – enjoys better access and a lower poverty rate. Yet, for the lagging provinces, the story is more mixed, with some areas featuring both golden and green colors with poverty mountains. However, in areas where the country's 30-year conflict was more present, as expected, higher poverty mountains go hand in hand with red and brown colors. ,

### 3.4 Inequality of Access to Infrastructure: Income Considerations

**One question that still remains is, among those who do have access to infrastructure services, how equitably is that access distributed.** This matters if policy makers are concerned about providing access regardless of income levels – a common political assertion. To answer this question, we compared income quintiles and access rates for Afghanistan and Sri Lanka. Figures 4a and 4b display the share of total connections – which is the number of connections owned by a quintile of income over the total connections in the country – for each type of infrastructure.

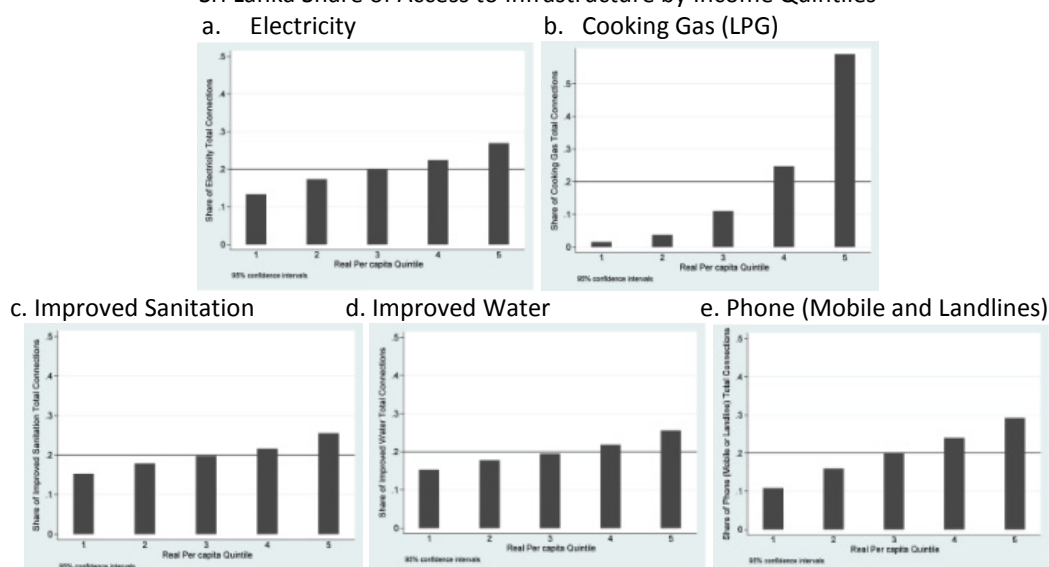
**In Sri Lanka and Afghanistan, the rich enjoy better access than the poor, but the countries differ greatly in how equal that access is across incomes.** In Sri Lanka, the difference in access across quintiles is small – all quintiles are close to the mean – indicating that there is an almost equal share of access to infrastructure regardless of income quintile. The opposite story is true in Afghanistan.

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<sup>15</sup> Maps could be generated for each infrastructure service, but this analysis is easier done via other means as discussed later in the paper.

**Figure 4a: Once Access is Achieved, Sri Lanka's Rich and Poor have Roughly Equal Shares ...**

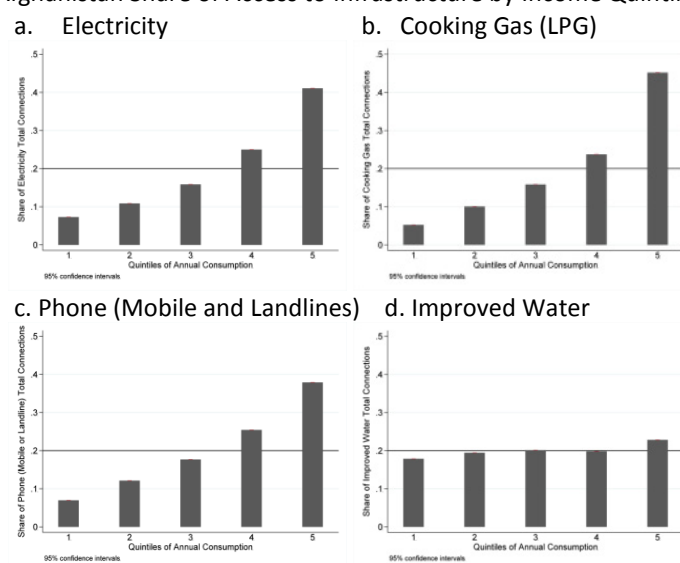
Sri Lanka Share of Access to Infrastructure by Income Quintiles



Source: Authors' calculations based in Sri Lanka HIES 2010.

**Figure 4b: ... Unlike the Rich and Poor in Afghanistan**

Afghanistan Share of Access to Infrastructure by Income Quintiles



Source: Authors' calculations based in Afghanistan NVRA 2008.

Note: The *share of total connections* correspond to the number of connections own by a quintile of income over the total connections in the country for each type of infrastructure.

**However, some services (like water) are more equitably distributed than others (like cooking gas) among those with access.** In Afghanistan, the equality of access across income quintiles is particularly striking for improved water. Whether poor or rich the shares of quintile over the total connection in the country hardly deviate from the mean. This is particularly remarkable given that access to improved water is very low in the country – significantly lower than all other countries in South Asia and the region's average. Regardless of years of conflict and scarcity of service, it seems that the Afghani society has emphasized sharing household access to water. But for cooking gas, in both Sri Lanka and Afghanistan, its use is particularly prevalent for the highest quintile, making it the rich's form of cooking.

The reason, as discussed, is the capital intensive nature of LPG, its reliance on network connectivity, and the easy availability of cheaper, albeit inferior, alternatives.<sup>16</sup>

## 4. Inequality of Access to Infrastructure across South Asian Generations

**So how unequal is access to infrastructure across time – that is, across South Asian generations?** After all, infrastructure investment choices to fill the infrastructure gap made today affect current and future generations. Moreover, not addressing the infrastructure gap threatens both welfare and economic growth in the medium and long term.

**Access to Infrastructure services is also weak in SAR when viewed in terms of how future generations will be affected.** If we drill down further into the data and isolate access rates for households with at least one child under the age of 15, we see that future opportunities for children are being seriously undercut by limited access (table 4).

### 4.1 The Human Opportunity Index: Access to Infrastructure as Opportunity

**Our main instrument for measuring the inequality of access to infrastructure across time is the Human Opportunity Index (HOI),** which was first published in 2008 and used to evaluate access in Latin America. It can be interpreted as a composite indicator of two elements: (i) the level of coverage of basic opportunities necessary for human development (such as access to primary education, water and sanitation, or electricity); and (ii) the degree to which the distribution of those opportunities is conditional on circumstances children are born into (such as gender, income, or household characteristics). This study calculates an HOI that is focused on basic infrastructure as opportunities and the importance of both improving overall access to it and ensuring its equitable allocation to achieve key socio-economic outcomes – such as early childhood development, education completion, good health, and access to information. So while in the previous sections, we delved into current realities of the lack of infrastructure service access and the disenfranchised, in the sections below we analyze how personal circumstances sustain this lack of access, thereby maintaining disenfranchisement across generations.

**The HOI essentially measures how personal circumstances impact a child's probability of accessing the services that are necessary to succeed in life.** This is critical because the opportunities a child gets throughout life are determined directly by the circumstances related to access to infrastructural services during the formative years – not necessarily to the child's personal decisions or level of effort. People often do not choose to live in polluted environments devoid of adequate infrastructure services, especially those key to their well-being. This situation is more acute for children as in their case access defines opportunity, precisely because, “children are not expected to make an effort to access basic goods by themselves,” (Paes de Barro et al, *ibid*). Moreover, empirical evidence indicates that the earlier the access in life, the more cost effective the results are in terms of final effects than having the access later in life (Heckman et al. 2010, among others). This is intuitively clear given the long gestation periods of most appropriate infrastructure investments.

**If societies aim for an equitable development process then they need to ensure that as many children as possible have access to basic opportunities.** Clean water, sanitation, and electricity are basic

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<sup>16</sup> This has been underscored in the literature as well (see Kojima et. al. 2011 and Kojima 2011).



opportunities with important welfare benefits. Children in households without clean water and sanitation are more prone to certain illnesses. For example, excess mortality of girls during infancy and early childhood is rooted in the lack of clean water, sanitation, waste disposal, and drainage. The lack of electricity at home puts a heavy toll on a child's learning process by limiting the hours of study at home. For children in isolated rural areas, getting to school and to health care facilities are a challenge, and hence costlier than for children in areas well connected by transport services.

## 4.2 Choice of Opportunities

**Opportunities are defined as the access to or use of infrastructure services.** The introduction of usage indicators is based on data availability and rests on the observation of services that exist in the area of the household but that are not utilized by household members due to habits, cultural traits, lack of information, or the need of additional conditions for use. Even among access indicators, we introduce measures that give a sense of quality of the service accessed by the household (compare, for example, access to improved water to access to piped water and then to tap water in the household). These complementary indicators are selected based on relevance but restricted by data availability, and thus are exploratory.

**Water:** The primary intent of water supply (and sanitation) interventions is to disrupt the transmission of water-related diseases to humans. A lack of basic water and sanitation leads to over one million child deaths annually from diarrhea alone (UNICEF, 2012). Water supply improvements can, in theory, affect development outcomes directly by providing sufficient water for basic hygiene to improve health, and indirectly through time saving, allowing for school attendance and employment. Health can improve as water-related diseases can infect people through the so-called “water washed” channel in which pathogens are incidentally ingested as a result of having insufficient water for bathing and basic hygiene (Zwane and Kremer, 2007). Secondly, a readily available water supply may lead to less need for household water storage—another opportunity for water contamination (Wright et al., 2004).

**Sanitation:** In terms of health and education outcomes, it makes a big difference having access to sanitation in general compared to not having it, but also the difference between having sanitation and a sewerage connection at home. If the benefits of sanitation are to be seized, there is still a long way to go in the sanitation ladder across South Asia. The lack of access to sanitation facilities either at households, school, or around places where people develop their economic activities, determine the prevalence of open defecation in some countries, particularly in India, where over 50 percent of households have members that practice open defecation.<sup>17</sup>

**Energy Use:** The available indicators of energy access are used to assess two different sets of expected effects on development outcomes. Electricity affects the time available for school work and for school attendance, as well as access to information. Gas for cooking, on the other hand, is expected to also have effects on time, but is usually tracked given its potential effects on health due to indoor air pollution.

**Telephones:** A recent study conducted by the UNDP places mobile phone penetration rates near 45 percent in low-income countries and 76 percent in lower-middle-income countries. The same study indicates that by 2015, ICTs should be accessible to everyone, resulting in the democratization of access

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<sup>17</sup> DLHS-3.

to innovative ICT with the potential to diminish barriers to access. The absorption rate of mobile phones by the world's poorest already indicates the incredible potential of cell phones in empowering developing communities to move up the socio-economic ladder. In developing countries, cell phones have taken on numerous roles, exceeding traditional uses of connectivity and browsing the internet. Rural communities and entrepreneurs use cell phones for making financial transactions, creating and managing client databases and coordinating fundamental business responsibilities. By creatively transforming the cell phone into a small-business enabler, rural communities have successfully created and attracted small-businesses ventures that would typically not survive in such dire environments.

#### 4.3 Choice of Circumstances for the Analysis: Rationale

**For this study we have selected four circumstances:** (i) household size, (ii) location (urban versus rural), (iii) education of household head, and (iv) gender of household head. These circumstances reflect previous inequality of opportunities studies and are in line with similar analyses that are part of the SAR Regional Flagship Report on Inequality of Opportunities (World Bank, 2014).

**Household size.** This is a circumstance that is out of a child's control and that will mostly be linked to use of services. While the role of size is not expected to be significant for our choice of opportunity indicators, we keep it in the analysis for comparison purposes in further iterations of the HOI calculation, and to identify areas of the country where this circumstance seems to have a relatively higher prevalence in explaining the HOI. This approach also links with the previous spatial analysis undertaken earlier in the paper.

**Location (urban versus rural).** This is key to understanding rural-urban migration patterns over time, given that services are concentrated in urban areas. The magnitude of location as a driver of inequality of opportunity is expected to be large in India, because 68 percent of the population (over 800 million people) still lives in rural areas, with about a 90 million rural population increase over the past 10 years.<sup>18</sup>

**Education of the household head.** Intuitively, one may expect households with heads that experienced higher education attainment would transmit the importance of education to their children. However, Azam and Bhatt's (2012) recent paper on intergenerational mobility in India using father-son data since 1940 finds that, "based on the estimated intergenerational elasticity, the transmission of educational attainment from father to son has decreased significantly across birth cohorts in the last 45 years," (p.29). But when they looked at the estimated correlation between father-son educational attainments, there is no trend. According to the authors, the explanation is in the evolution of dispersion in educational attainment of both generations. So as to clarify the importance of household heads' education attainment, we keep this circumstance in the analysis.

**Gender of the household head.** South Asia gender data are particularly skewed against females. We thus choose this variable to understand if gender bias impacts children opportunities in the region. This element is expected to be of relatively low importance compared to the other three circumstances

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<sup>18</sup> Census of India, 2011.

driving opportunity.<sup>19</sup> Even so, we will look at a variation of the relative weight of gender in inequality of opportunities across states and districts in India.

#### 4.4 Calculation of HOI, Dissimilarity Index, Penalties, and Shapley Decompositions

**The key to calculating the HOI is the dissimilarity index.** This is originally a demographic measure of evenness widely used in analysis of social mobility, sociology in general, and typically applied to dichotomous outcomes. Paes de Barro et al. (ibid.) define the dissimilarity index (D-index) as the weighted average of absolute differences of group-specific access rates ( $p_i$ ) from the overall average access rate ( $\bar{p}$ ), or:

$$(1) D = \frac{1}{2\bar{p}} \sum_{i=1}^n \beta_i |p_i - \bar{p}|$$

The D-index will then be expressed in percentage terms, with a value between 0 and 1. A value of zero indicates that access rates for all groups considered are the same, while positive values indicate that certain groups of individuals have a lower probability of access to the infrastructure service considered.

In practical terms, the dissimilarity index that we calculate will reflect the percentage of the coverage rate of a particular opportunity that has to be discounted in order to obtain the HOI, i.e.:

$$(2) HOI = \bar{p}(1 - D)$$

While the penalty (P) is the difference between coverage rates and the HOI:

$$(3) P = \bar{p} - HOI$$

As equation (2) shows, the HOI can be improved either by an increase in coverage (which is still bounded at 100 percent universal access, and so the more people have access, the less likely is that a particular segment of population is being left behind), or by a closer to zero dissimilarity index. At higher levels of coverage for a service, there is less room for a dissimilar distribution of access across groups. However, the dissimilarity index, as we will see, varies across opportunities and units of analysis, even at similar levels of coverage.

**Next, we calculate the contribution of each circumstance to observed inequality of opportunities across households,** following Hoyos and Narayan (2010). This is done through Shapley decompositions on the dissimilarity index. These decompositions, originally proposed by Shorrocks (1999), show how much inequality changes as a consequence of adding an additional circumstance. Because circumstances are correlated with each other, the change in inequality when a circumstance is added depends on the initial set of circumstances to which it is added. To calculate the impact of each circumstance, the average of all possible changes to different combinations of other circumstances is found.

**Finally, we calculate the total unique contribution of each circumstance to the dissimilarity index, along with a percentage of contribution that sums 100 percent.** By construction, the closer access gets to 100 percent of households, the less room for inequality there is. Therefore, as coverage increases, we

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<sup>19</sup> We settle for 'gender of the household head' as our proxy for gender weight in the HOI because the data available does not allow exploring restrictions in the access and use of services across household members. The low prevalence of female-headed households, however, contributes to a low weight of this variable in the HOI.

expect lower values of the dissimilarity index. However, coverage does not grow equally for different circumstance groups, and similar levels of coverage might present radically different levels of inequality of opportunity.

## 4.5 Inequality of Opportunity in the Access to Infrastructure Services in SAR

### 4.5.1 HOI across the region

The results show that the better a country's coverage – in sanitation, water, energy source, and communications – the more equitable the access, and thus the higher the HOI (table 4). In addition, in some cases, the HOI is lowered more by the problem of unequal access (measured by the dissimilarity index) than by insufficient coverage. Take the case of *improved sanitation*. As expected, countries with the highest coverage (the Maldives, Sri Lanka) feature the lowest dissimilarity index, and therefore, HOI is very close to the coverage. At the same time, countries with low levels of coverage (like Bangladesh) are associated with higher dissimilarity indexes. However, if we take two similar access rates, as in India (36 percent) and Nepal (37 percent), we see a significant difference in how that access to sanitation is distributed – with Nepal (0.14) more equal than India (0.24), which results in India having a lower HOI (0.27) than Nepal (0.32). This also reflects the spatial story told previously. Also, a country with higher coverage like Pakistan features virtually the same dissimilarity index as India, and a substantially higher HOI index than Nepal. In the case of access to *improved water*, rates are high enough to guarantee a low dissimilarity index. *Electricity* also follows the pattern of a decreasing dissimilarity index as coverage is higher, but in a less than proportional manner.

### 4.5.2 Contribution of circumstance to HOI in the region

**Can we ascertain how much individual circumstances drive the HOIs for each type of infrastructure?** We try to answer this question by looking at all 9 types of infrastructure, then calculating the HOI (for each indicator (top panel), and then the contribution of each circumstance to the HOI (figure 5).

**A few patterns stand out, which point to better access for the most basic indicators than the more advanced ones, and the importance of location and education of the household head together as the key explanatory variables, although location tends to dominate:**

- Indicators of use (cooking fuels) and indicators linked to a higher quality of access (no fossil for cooking, phone, mobile phone, sewerage, and piped water) register a significantly higher inequality of opportunity than more basic access indicators (improved water source, improved sanitation, and access to electricity).
- Two factors – the location of the household (urban versus rural) and the education of the household head – explain over 70 percent of the HOIs across countries and across indicators (most of the time, over 80 percent).

**Table 4: Better Coverage Typically Goes with More Equitable Access and Thus Higher HOIs**  
*Access to Infrastructure Services and Human Opportunity Index for household with children under 15 years old*

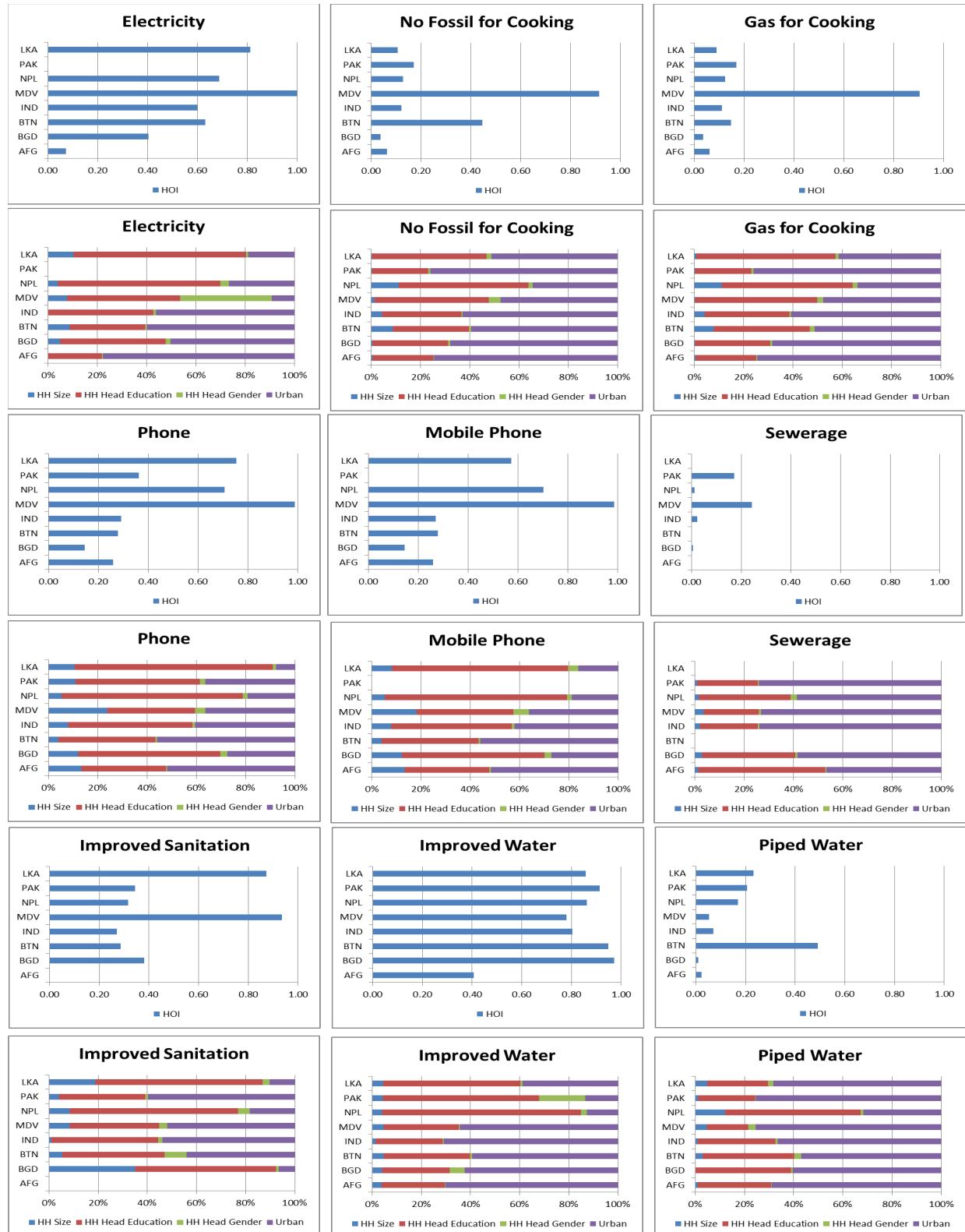
Country	AFG	BGD	BTN	IND	MDV	NPL	PAK	LKA
Year	2008	2006	2007	2007	2009	2011	2006	2010
<b>Sanitation</b>								
<b>Sewerage</b>								
Coverage	0.01	0.02	.	0.06	0.41	0.03	0.28	.
Dissimilarity Index	0.81	0.68	.	0.60	0.40	0.56	0.38	.
HOI	0.00	0.01	.	0.02	0.24	0.01	0.17	.
<b>Improved Sanitation</b>								
Coverage	.	0.45	0.38	0.36	0.94	0.37	0.44	0.90
Dissimilarity Index	.	0.15	0.24	0.24	0.01	0.14	0.23	0.03
HOI	.	0.38	0.29	0.27	0.93	0.32	0.34	0.87
<b>Water</b>								
<b>Piped Water</b>								
Coverage	0.05	0.04	0.57	0.12	0.16	0.21	0.29	0.29
Dissimilarity Index	0.55	0.74	0.14	0.42	0.67	0.18	0.29	0.20
HOI	0.02	0.01	0.49	0.07	0.05	0.17	0.21	0.23
<b>Improved Water</b>								
Coverage	0.46	0.98	0.96	0.83	0.86	0.88	0.92	0.88
Dissimilarity Index	0.11	0.00	0.01	0.03	0.09	0.02	0.01	0.02
HOI	0.41	0.97	0.95	0.80	0.78	0.86	0.91	0.86
<b>Energy Source</b>								
<b>Gas for Cooking</b>								
Coverage	0.16	0.10	0.22	0.22	0.92	0.21	0.32	0.16
Dissimilarity Index	0.62	0.64	0.33	0.50	0.02	0.41	0.47	0.43
HOI	0.06	0.03	0.15	0.11	0.90	0.12	0.17	0.09
<b>No Fossil for cooking</b>								
Coverage	0.17	0.10	0.57	0.24	0.94	0.22	0.32	0.18
Dissimilarity Index	0.62	0.63	0.22	0.49	0.02	0.41	0.47	0.41
HOI	0.06	0.04	0.45	0.12	0.92	0.13	0.17	0.11
<b>Electricity</b>								
Coverage	0.17	0.50	0.72	0.68	1.00	0.75	.	0.85
Dissimilarity Index	0.58	0.20	0.12	0.12	0.00	0.08	.	0.05
HOI	0.07	0.40	0.63	0.60	1.00	0.69	.	0.81
<b>Communications</b>								
<b>Mobile Phone</b>								
Coverage	0.36	0.24	0.39	0.39	0.99	0.76	0.45	0.80
Dissimilarity Index	0.27	0.38	0.29	0.26	0.00	0.08	0.20	0.06
HOI	0.26	0.15	0.28	0.29	0.99	0.71	0.36	0.75
<b>Phone (Landlines and Mobile)</b>								
Coverage	0.36	0.23	0.39	0.37	0.99	0.76	.	0.63
Dissimilarity Index	0.27	0.38	0.29	0.27	0.00	0.08	.	0.09
HOI	0.26	0.15	0.28	0.27	0.99	0.70	.	0.57

Source: Authors calculation based on NVRA 2008 for Afghanistan, MICS 2006 for Bangladesh, LSMS 2007 for Bhutan, DLHS-3 for India, DHS 2009 for Maldives, DHS 2011 for Nepal, DHS 2006 for Pakistan and HIES 2010 for Sri Lanka. All estimation represent the proportion of access in the sample of households with children under 15 years.

Note: All piped water is restricted to piped water in the premises. We do not present the rate of access for Afghanistan because we cannot differentiate between latrines with and without slab. For Bangladesh improved water rate of access, we did not use the assumption made by JMP where they discard 20% of protected wells due to arsenic contamination. For Bangladesh improved sanitation data, in order to make rates comparable, we include JMP pit latrines without slab in the category of improved sanitation (when is categorized as unimproved). For further information about this changes in the JMP methodology, check JMP data by country ([http://www.wssinfo.org/documents-links/documents/?tx\\_displaycontroller\[type\]=country\\_files](http://www.wssinfo.org/documents-links/documents/?tx_displaycontroller[type]=country_files)). Given that there is no information about landlines in Bhutan, the definition of phone (mobile and landlines) is the same as mobile phones. Sri Lanka's sewerage connection is not presented because it is not identifiable in

the data. In Pakistan there is no information about the tenance of mobile of phones in the household. The lack of information about access to electricity in Nepal and Pakistan is caused by significant differences with the official data (World Energy Outlook,) which motivates us to think that they do not have comparable definitions of access to electricity.

**Figure 5: Location and Education Top Circumstances Explaining SAR's HOI Outcomes**



**A closer look at the three energy indicators (access to electricity, use of gas for cooking, and biomass for cooking), shows location and household head education to be the dominant factors.** Among them, access to electricity features the most equitable access distribution, by far, although regrettably, we lack indicators of the quality of that access (in terms of number of hours of electricity each day, or information on shortages). With cooking fuels (the usage indicators), we see a close pattern between them, plus higher dissimilarity indexes than for electricity. As for circumstances explaining the HOI variations in access to energy sources, in Afghanistan, Bangladesh, Bhutan, and India, location (urban/rural divide) dominates, while the education of the household head dominates in Sri Lanka and the Maldives for electricity and cooking gas.

**For the rest of the indicators, similar patterns emerge.** The role of location can be easily understood, because improving access to infrastructure in urban areas allows governments and private sector to reach higher concentrations of households, thereby reducing per capita cost. But the role of education needs to be further scrutinized, given that it could be a proxy for access to information, for household income, or for location beyond the urban/rural category.

#### *4.5.3 A sub-national look at Inequality of Opportunities*

**At the state or district level,** Andres et al. (2013) presented regional maps with the inequality of opportunity for SAR for access to water, sanitation, and electricity for all countries – suggests that location is a dominant factor. But while there are areas notorious for low coverage rates (for example, Balochistan in Pakistan, Afghanistan’s southwest, Sri Lanka’s northeast, or parts of Bihar and Madhya Pradesh in India),<sup>20</sup> each of the three indicators seems to have a concentration of higher access rates across particular areas (such as the Ganges area for improved water sources; Kerala, Himachal Pradesh, and Punjab in India, together with areas around the capital cities of the region, for improved sanitation; and the latter together with Gujarat and north of Delhi for access to electricity). This observation calls for a more detailed look at subnational level coverage and HOIs, which is what we do for four countries – Afghanistan, Bangladesh, Bhutan, and India – comparing the national capital (where available) with other areas.

##### *4.5.3.1 Afghanistan<sup>21</sup>*

**Kabul has the highest coverage of households in the electric grid (62 percent), with an HOI of 53 percent.** The capital also leads in access to improved water sources (71 percent), with an HOI of 66 percent. Location explains most of the HOI for electricity and access to water, but household size dominates for explaining the HOI for sanitation services.

**Now consider Helmand province in the border with Balochistan (Pakistan), an area witnessing increased conflict, and where there is a large production of opium.** Even having the Helmand river flowing across the province, the mainly desert area registers the lowest access to improved water sources (only 6 percent) of households, and highly unequal access to it, resulting in a HOI of 4 percent. It ranks 9th in access to electricity (11 percent coverage) and access is highly unequal within the province,

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<sup>20</sup> Coincidentally or not, these are areas where conflict was or has been most intense.

<sup>21</sup> In the case of electricity access, we have information for only 20 out of 34 provinces.

with a dissimilarity index of 49 percent, for an HOI of 6 percent. Location is the key explanatory factor for all three coverage rates.

**In Farah, a western province at the Iranian border, eminently rural and tribal, multiethnic, sparsely populated, but relatively conflict-free, with local authorities exerting local control,** access to electricity is virtually null (1 percent). However, it has a 59 percent access to improved water sources rate, with an HOI of 57 percent. Here, education of household head is the chief explanatory factor.

#### 4.5.3.2 Bangladesh

**Dhaka district has virtually universal access to improved water sources (100 percent), very high coverage rates of electricity (93 percent) and middle access to telephone (55 percent).** However, the capital ranks 36th (out of 64) in access to improved sanitation, with 46 percent coverage, and 35 percent HOI. The key explanatory factor for all indicators is education of the household head.

**Kurigram district in the far north is one of the poorest districts in Bangladesh.** It has the lowest electricity access rate in the country (15 percent), with a HOI of 9 percent, and only 7 percent of households have access to a telephone, with a HOI of 3 percent. However, its HOI for improved sanitation is higher (45 percent) than in Dhaka, even though they have the same coverage rates. The key explanatory factor for the indicators is education of household head, followed by household size for sanitation, and location for electricity.

**The industrial and business center of Narayanganj, on the other hand, has the highest electricity access rate of the country (93 percent) with a HOI of 91 percent,** but one of the worst rates of access to improved sanitation at 28 percent, for an HOI of only 24 percent. The factors explaining HOI follow the exact same pattern as in the case of poor Kurigram.

#### 4.5.3.3 Bhutan

**Thimpu is the district with the highest coverage rates for improved water, improved sanitation, and electricity.** The largest inequality in access is registered for improved sanitation (58 percent coverage but a 49 percent HOI). The key explanatory factor for HOIs is education of the household head, except in the case of access to improved water sources, for which location equally matters.

**The Zhemgang district hosts the poorest areas of the country,** most of which is considered a protected area. Electricity access reaches 44 percent among households, but it is highly unequally distributed, featuring an HOI of 30 percent. The same applies to access to sanitation, as the access rate of 13 percent drops to an HOI of only 4 percent. Education of household head is the dominant circumstance.

#### 4.5.3.4 India

**In Delhi, 93 percent of households have access to improved water sources, and 99 percent to electricity, at least for some time during the day.** However, although access to improved sanitation is over the country average (63 percent), the HOI drops to 53 percent. For all indicators, the key explanatory factor is the education of the household head.

**Bihar, one of the poorest states in India, has 93 percent access rates to improved water and 92 percent HOI.** But it has the worst access rates and high dissimilarity index for both improved sanitation



(15 percent coverage, 8 percent HOI) and electricity (26 percent coverage, 17 percent HOI). Here, too, education of household head explains most HOIs.

**Maharashtra, one of the richest states, underperforms Bihar in access to improved water (82 percent coverage, 76 percent HOI),** and only ranks 25th and 23th in access to improved sanitation and electricity. In Maharashtra, however, location is the dominant factor explaining the HOIs.

#### 4.5.3.5 Key sub-national patterns

**At the state or district level, the role of education of the household head gains in importance compared to location – relative to the findings for the regional – as the key circumstance explaining the HOIs, although together they are still the dominant factors. In addition, household size also registers at a higher level than in the regional survey, primarily for sanitation.**

**An interesting pattern at the infrastructure subsector level emerges from this country level analysis, which needs to be corroborated by further research.** As discussed, urban environments provide the density needed to enable infrastructure services in a cost effective manner. The density factor is particularly important for grid type infrastructure such as electricity and piped water which are direct benefits to households. Extending a grid based service like power to a nearby household is less expensive than bringing power to an isolated rural household. In the case of piped water, this is not even discussed by planners for being so prohibitive. Of course, this is limited by congestion and other public bads but it is closely related to agglomeration benefits facilitated by urbanization due to the importance of connectivity. As one expands the definition of adequate water services in urban environments to include these under improved water, the HOI analysis shows that rural areas become less penalized in terms of inequality.

**Improved sanitation breaks the above pattern and one can only theorize the reason at this stage.** As discussed, individual households tend to solve their own sanitation problems by transferring their sewage to their neighbors by polluting their neighborhood or downstream areas; therefore, there is little incentive to invest on adequate sanitation from an individual household perspective beyond the gates of one's own property. Scarce household money is better invested in securing direct benefits to one's household such as power and water. It is less surprising to find out that size of household is an important explanatory factor in choosing improved sanitation facilities. In a sense, the density logic applied at urban environments applies in the case of individual households as well. Yet, the apparent inverse relation between higher education and improved sanitation is quite surprising. Better education of household head is often linked to higher income, urban dwelling and hence access to grid level infrastructure. It is interesting to realize that it can also be linked to a greater degree of public bad like pollution. Several studies argue that education has little positive externalities. The lack of appropriate sanitation in urbanized environment may thus at least in part be explained by this lack of correlation between higher education and positive externalities.

#### 4.5.3.5.i A Look at State-level Results in India<sup>22</sup>

**For India, these differences in access for certain households at the state level exacerbate the problem of low coverage rates of these services at the country level.** The reality is that despite significant improvements in access to water and electricity, access to infrastructure services in India remains

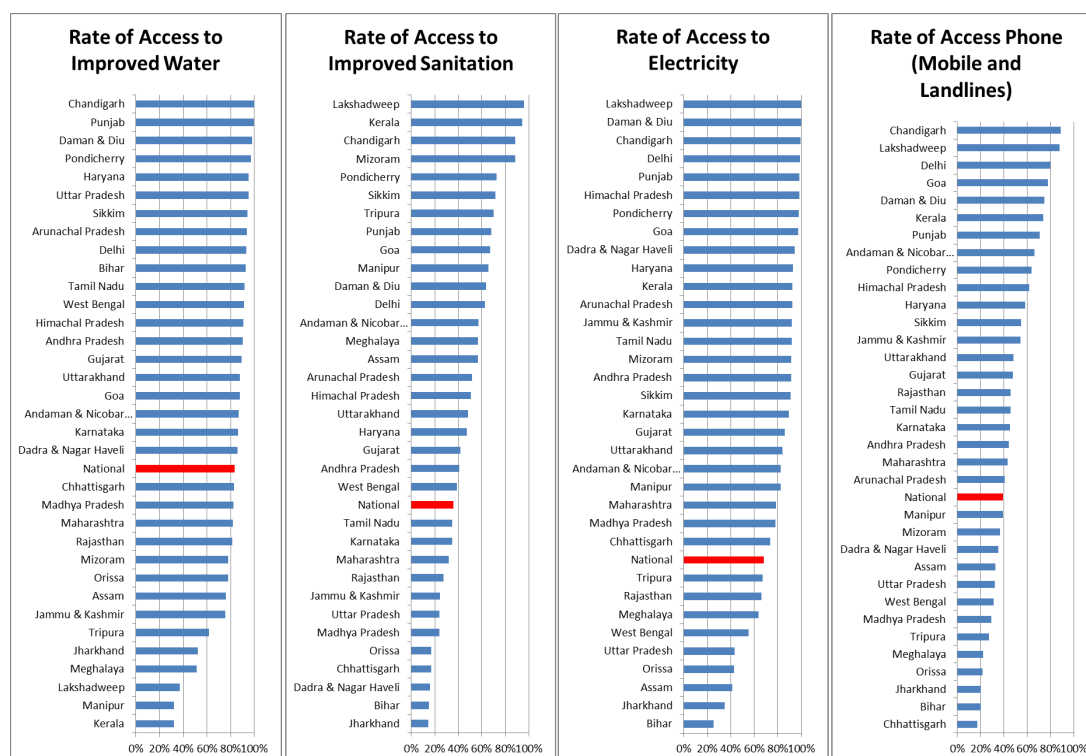
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<sup>22</sup> To keep the analysis of data manageable, we report state-level figures for only three indicators of opportunity: access to improved water sources, access to improved sanitation, and access to electricity.

mostly low in many areas with very heterogeneous results. While close to 70 percent of households (with children under 15 years old) in India have access to electricity, less than half of the households (with children under 15 years old) have access to improved sanitation, and only a fraction of those to a sewerage connection. Sanitation access data are heavily discounted owing to inequality of access across circumstance groups; a similar pattern emerges for use of energy sources.

**A look at coverage of infrastructure services across Indian states shows high variability and uneven performances.** Take the cases of access to improved water, improved sanitation, electricity, and phones (figure 6). We observe how a relatively high national coverage of access to improved water sources (83 percent) contrasts with the reality of two states (Manipur and Kerala) with less than a third of their households (with children under 15 years old) with access to it. In the case of sanitation, ten states have coverage rates lower than 33 percent.

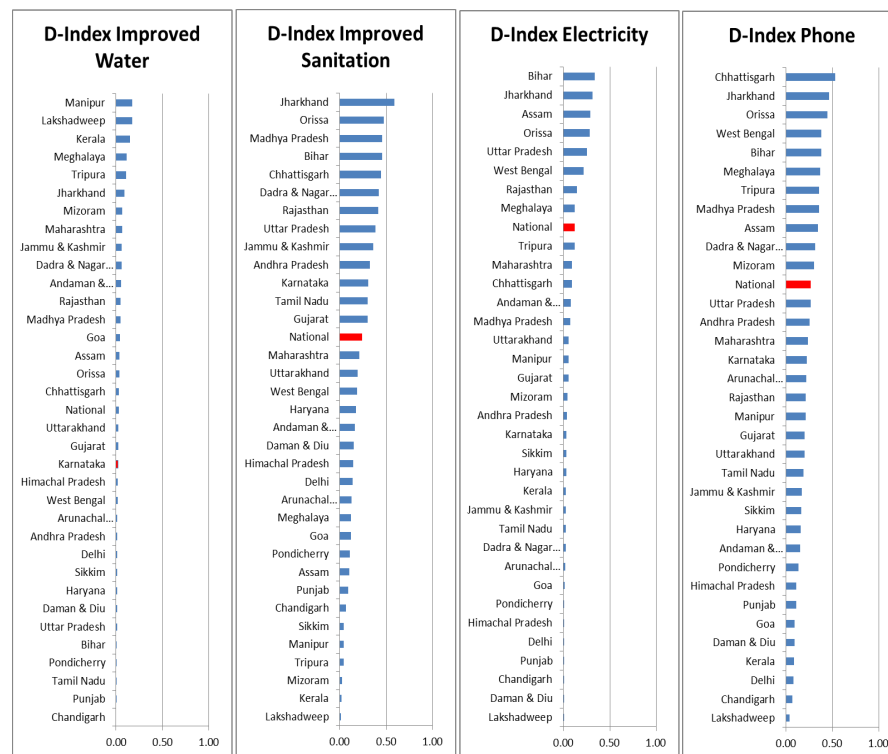
**Figure 6: Access in India to key services varies greatly**  
*Coverage of improved water, sanitation and electricity services, State-level*



Source: DHLS-3 India

**Another way to understand the presence of inequality of opportunities across states is by comparing the magnitude of the dissimilarity index (D-index) across states and the resulting HOI – in effect, permitting the identification of areas in the country where inequality of access can be targeted as a policy element.** As figure 7 shows, there is significant inequality in the access to improved sanitation services across states, compared to other services. Jharkhand, for example, with a coverage rate of 15 percent, receives a penalty of over 50 percent when the inequality of access across circumstance groups is considered. It also has the second largest D-index for access to electricity, while Manipur has the largest D-index for access to improved water sources. While this paper does not discuss inequality of opportunities at the district level, it should be noted that the same variance in coverage and HOI values can be found among districts within the same state. For example, access to sanitation has its lowest coverage rate in Leh Ladakh district, Jammu and Kashmir state of the Himalayan region, at 2.5 percent.

**Figure 7: Dissimilarity Index Varies Greatly across Indian States and among Different Services**  
D-index for improved water, sanitation and electricity services, State-level



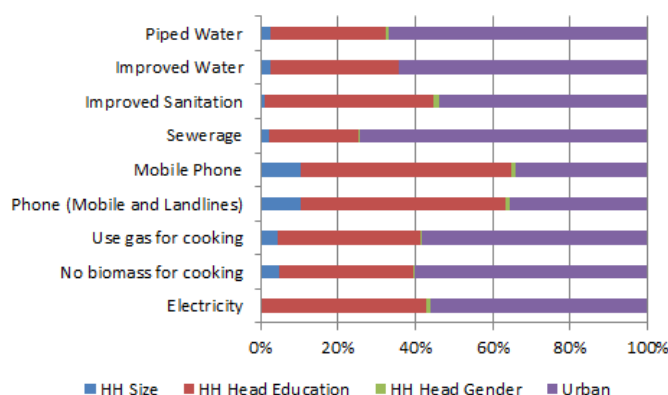
Source: DHS 2010

#### 4.5.3.5j Contribution of circumstances to inequality of opportunities

**Which circumstances contribute the most to inequality of opportunity at the state level?** Education of the household head and location are the dominant ones (figure 8). The location factor is to be expected given that rural households are typically harder to reach with infrastructure services. However, the education one is more difficult to explain, considering that this effect is net of location, caste, and other factors. A possible explanation is that even among rural areas there are different levels of remoteness, which in turn is also correlated with lack of access to education services, more prevalent poverty, and by extension, less access to infrastructure services. In the case of indicators of use (use of fossil fuels, use of gas, open defecation), the question remains if the role of education of the head of household is linked to a lack of alternatives, the prevalence of habits, or lack of information.

**Figure 8: Household Head Education and Location Dominate India's HOI Outcomes**

Contribution of circumstances to Inequality of Opportunity in India, country level

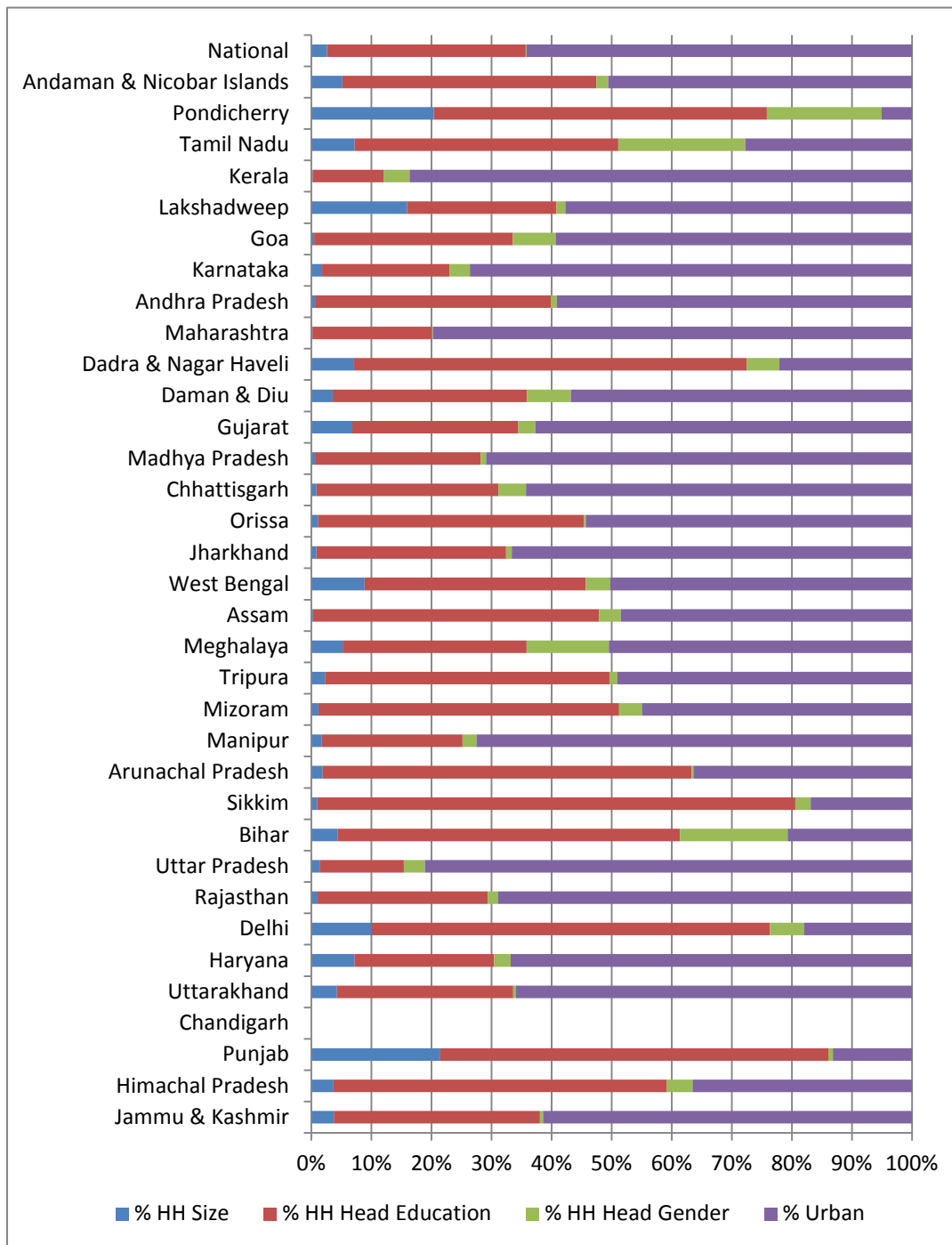


Source: DHS, 2010

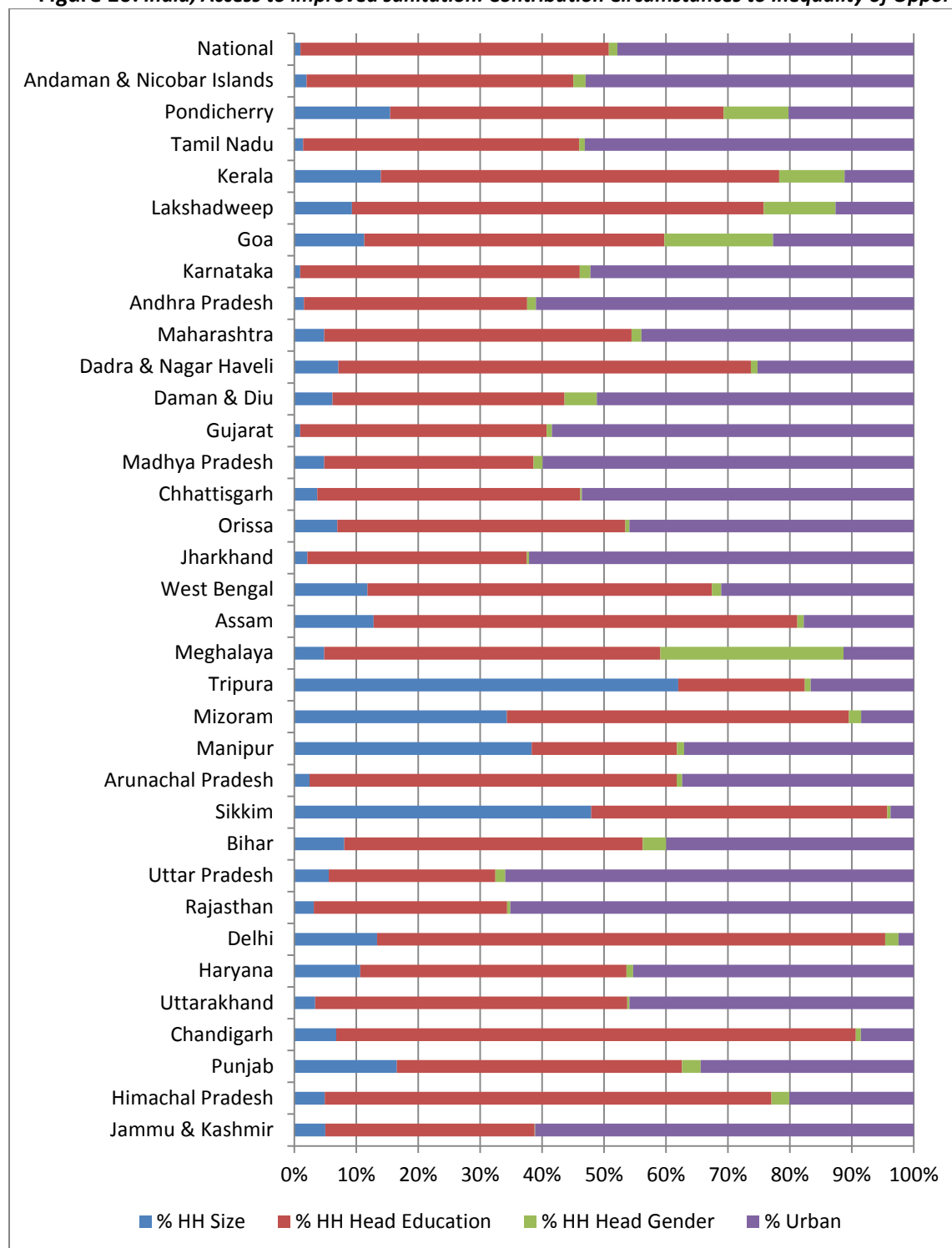
**The final step is to identify the relative contribution of each circumstance to the D-index in all Indian states, and through it, to inequality of opportunity (figures 9 to 12).** While location and education of the household head are also the dominant circumstances in explaining HOI across states, the analysis spotlights some finer variations.

- *First, gender appears to be a factor, unlike at the country level.* In particular, access to services is not evenly distributed among female and male headed households in a number of states. For those services with the highest coverage rates at the national level (water and sanitation), the highest contributions of gender to inequality tend to be clustered around states with high coverage of the service. In the case of access to water, gender contributes significantly to inequality in Bihar, Tamil Nadu, and Pondicherry (around 20 percent). For access to electricity, this is the case for Pondicherry, Lakshadweep, and Sikkim (around 10 percent). In the case of access to improved sanitation, the contribution of gender is consistently low, with the exception of a few states such as Meghalaya (about 33 percent) and Goa (around 20 percent). The same lower access is found for phones, with the contribution of gender found in Pondicherry (about 8 percent).
- *Second, location plays a smaller role in inequality – and education of the head of household a larger role –* where higher access rates exist. This is consistent with the patterns of infrastructure expansion, which tends to serve population agglomerations first, and then progressively expand to the periphery.

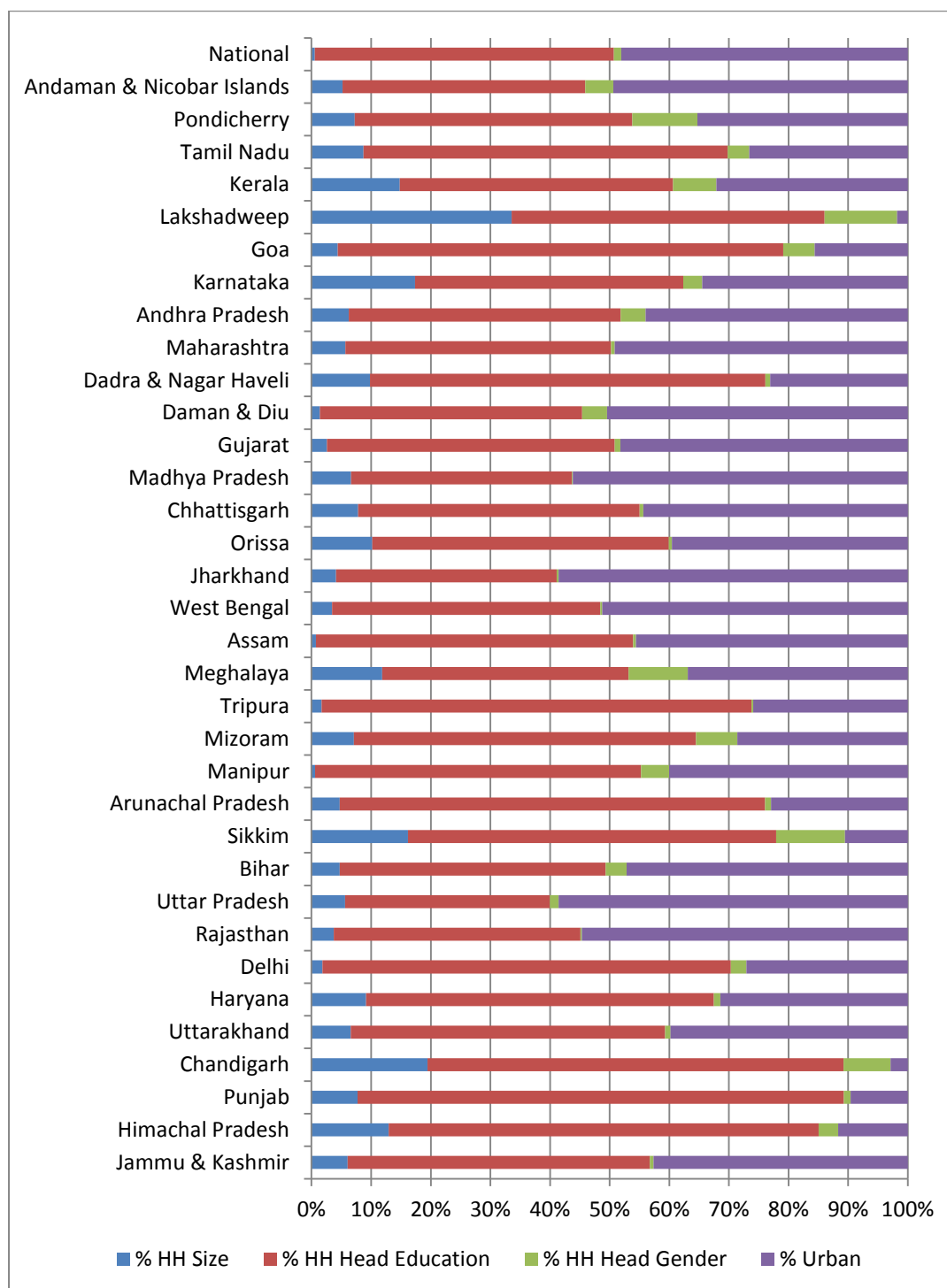
**Figure 9: India, Access to improved Water: Contribution of Circumstances to Inequality of Opportunities**



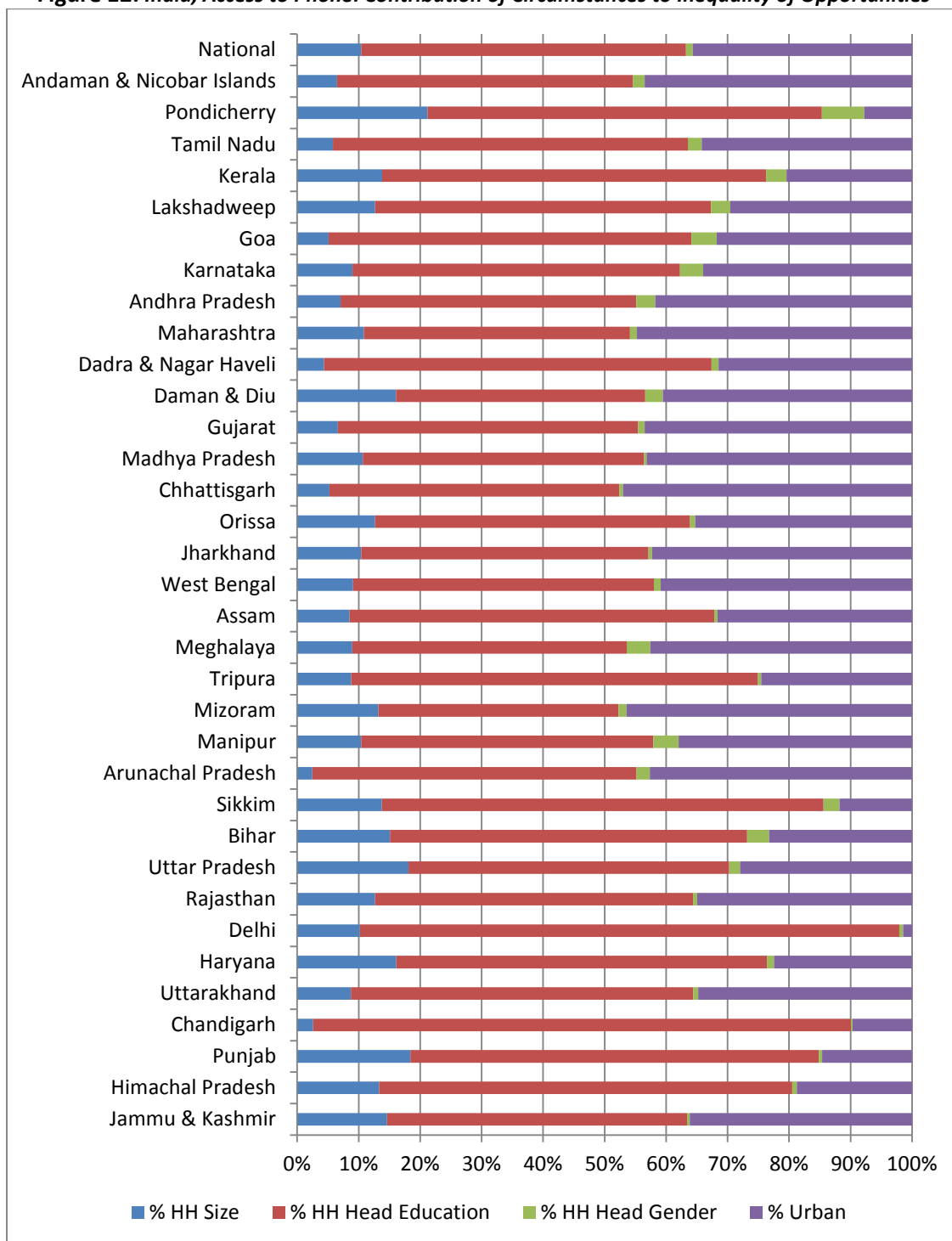
**Figure 10: India, Access to improved sanitation: Contribution Circumstances to Inequality of Opportunities**



**Figure 11: India, Access to electricity: Contribution of Circumstances to Inequality of Opportunities**



**Figure 12: India, Access to Phone: Contribution of Circumstances to Inequality of Opportunities**



Source: DLHS-3 2007/2008.



## 5. Policy Options to Address Inequality of Access to Infrastructure in South Asia

### 5.1 Key Principles to Guide Policies

**Access is fundamental, but usage determines impact.** That is why policy makers should complement access to infrastructure with policies to incentivize the use of services, or make potential benefits more obvious or attainable. One way to do this is to focus on subsidizing (implicitly or explicitly and with sunset clauses) the infrastructures that provide the greatest public benefit (public good) in contrast to those that provide large private benefits. This should be true across infrastructure sectors as well as within sectors.

- *For water*, rather than broadly subsidizing provision for which subsidies are often captured by richer groups in society, a municipal government would choose to subsidize flood control.
- *For energy*, a large country like India with a large energy gap may choose to subsidize cleaner sources like solar as opposed to coal fire plants. After all, if electricity is expected to be followed by the adoption of cleaner energy sources, there are several steps that need to occur in between.
- *For sanitation*, given the importance of the location of services, maintenance, and campaigns to promote use, a policy maker may choose to subsidize information provision to address open defecation rather than off-site sewage system provision. If subsidies are provided for off-site sewage system provision, preference should be given to treatment and connection to poor households or a condominial type system rather than tariffs.

**Ability-to-pay for access to infrastructure services cannot be the only instrument to determine provision.** Infrastructure services have strong market failure characteristics, underscoring the need for adequate regulation. Some infrastructures are still close to natural monopolies (such as pipe water and off-site sanitation services). Many are associated with strong externalities (negative and positive) and public goods (and bads) characteristics, as in the case of a lack of sewage treatment or a lack of access to cooking gas. Information issues also abound. Moreover, since infrastructure may act as a spur to economic growth, relying on the ability-to-pay criterion might undercut efforts to reduce poverty.

Another way is to focus on improving women's access to services, as the improvement in household outcomes can be larger when women benefit fully from access. Still another way is to focus on enhancing quality and maintenance, which are major issues in South Asia – where there are in average 42 power shortages a month and 21 water shortages a month.

**Yet, some infrastructure programs are too costly to be sustainably implemented without cost-recovery mechanisms that allow them to be self-supporting.** The trade-off between providing access to infrastructure services and fully charging for these services is seldom an easy one to equate. It involves understanding the economic characteristics of particular infrastructure sectors and the technology available for provision under different physical, political, and socio-economic conditions. Take the case of piped water provision, which is a private good. It has important market failures associated with it, but essentially individual households have clear incentives to pay for a superior service compared to other forms of getting water in an urban environment. Yet, piped water is seldom charged to attain full cost recovery and often relies on direct or indirect subsidies that burden public budgets. Nonetheless, the expansion of piped water provision is often part of political manifestos during election campaigns. Now

take the case of flood control, which is a public good. Direct cost recovery mechanisms like tariffs are difficult to design, but the lack of adequate flood control in a locality for example can cause substantial costs to households via the loss of private assets and lives. Budgetary allocation for flood control is often inadequate and the service is underprovided.

**The likely aim of the policy maker is to attain a certain degree of balance in infrastructure access (especially basic infrastructure), while allowing for wealthier populations to shoulder most of the burden of improving coverage for all.** Given the equality achieved in improved water in South Asia, one would be tempted to conclude that this objective is present as the service expands. But this conclusion might conceal rent-seeking behavior, where the wealthier capture proportionally larger amounts of rents that otherwise could be used for expansion and quality improvement for all and not just a few. The literature also argues that infrastructure service expansion is closely linked to rent seeking, since richer districts are better able to lobby the government for infrastructure provision (Cadot et al., 1999).

**Although subsidies may improve affordability among underprivileged groups, they can also have the effect of increasing income inequality.** Subsidies tend to be captured by those who have political connections, which, at least among unconnected households, tend to be the more middle class households. Wodon and Ajwad (2002) found that in Bolivia and Paraguay, the marginal benefit of improved access to a service tended to be two to three times higher among the upper two quartiles. Thus, while all income quartiles benefited from decentralization, the richer 50 percent benefited more than the poorer 50 percent, a net effect that would tend to increase income inequality. Estache (2005) points out that in Latin America as much as 60 to 80 percent of cross-subsidy schemes "were aimed at households well above the poverty threshold, while as much as 80 percent of poor households failed to benefit." Thus, it is not surprising that even as absolute levels of connection increase, regressivity in access to infrastructure may still prevail.

## *5.2 Menu of Instruments for Poverty and Access to Infrastructure Services*

**Subsidizing connection rather than service consumption may help target the poor.** To avoid some of the drawbacks of subsidies, policy makers can adopt measures that reduce the cost of providing network services or improve the ability of poor households to pay for service at a given cost (Komives et al., 2005). These would be available only to unconnected households, reducing or eliminating the price customers have to pay to connect to the system. Alternatively, policy makers can subsidize lower service levels that the better off find less attractive, such as social connections.

**Another set of possible instruments is targeted interventions.** Usually these instruments are centered narrowly on a certain district or group that is perceived as underserved. This approach has the advantage of fewer spillover effects – that is, there is less likelihood that the intervention ends up benefitting those who were not intended to be its beneficiaries. However, because these interventions are operating only within impoverished and underserved areas, they tend to face issues like inadequate staffing, funding, technical capacity, and lack of political will (Menéndez, 1991).

**A broader approach to address rent seeking could be institutional rather than infrastructure service specific.** There are also a number of options to design programs to reduce elite capturing and increase the power of impoverished groups to allocate resources toward their priorities. These include:

- *Institutional re-centering.* Organizations can be created whose primary concern is to reduce poverty through providing infrastructure. For instance, Bolivia's Emergency Social Fund was a

temporary organization that was created to finance infrastructure projects in underserved communities.

- *Community participation.* Incorporating transparent mechanisms for underserved people to easily provide input into the design and decision-making process behind infrastructure projects could potentially allow them to compete with the more informal mechanisms that richer populations use to influence decision-making (Menéndez, 1991)<sup>23</sup>.

**Innovative mechanisms are needed to make policies more effective.** Service delivery mechanisms need to evolve to respond to the challenges of coverage, affordability, use, and sustainability. This is particularly important given that poor households tend to pay more for services when they have to obtain them through non-network solutions. For example, community-based organizations and user groups can contribute to planning and operations; NGOs can help with monitoring and evaluation, promoting social accountability and raising awareness; and the private sector can get involved with investment and delivery (Andres and Naithani, 2013). These alternative mechanisms, which are context-specific, are becoming part of the policy toolkit as they are tested and mainstreamed.

## 6. Conclusions

**If South Asia hopes to meet its development goals and not risk slowing down – or even halting – growth and poverty alleviation – it is essential to make closing its huge infrastructure gap a priority.** Even though SAR's economic growth follows that of EAP, its access to infrastructure rates (sanitation, electricity, telecom, and transport) are closer to that of SSA – the one exception being water, where SAR is comparable to EAP and LAC. As discussed, this is closely related to SAR's urbanization level and the attractiveness cities may exert on people. A slow urbanization process also means at least in part forgoing agglomeration benefits at current technology levels.

**While the regressivity of infrastructure services is clearly present in South Asia, the story that emerges is heterogeneous and complex.** Countries with higher per capita income (like the Maldives and Sri Lanka) enjoy better access to infrastructure services both spatially (geographically within the country) and income wise – even though conflict areas are clearly worse off. That said, the widespread use of firewood for cooking, particularly among the poor, is somewhat surprising, although it may reflect a policy choice, which in turn may have dire consequences in the intergenerational transmission of poverty. Among infrastructure sectors, water is the most equally distributed in spatial terms, and sanitation, energy, and phones the least – although in countries like India the telecom revolution has arrived with phone access rising rapidly. Within a country, leading regions (those with a lower poverty level) generally mean better access but lagging regions (those with a higher poverty level) do not necessarily mean worse access. Of course, the quality of the services also matter, and Sri Lanka – which has the best educated population in SAR and a benign geography – scores high in that regard, too.

**The challenge of increasing access to infrastructure services across South Asia is compounded by the inequality in the distribution of existing access for households with certain characteristics:** (i) located in rural areas; (ii) with household heads that have not passed through the education system; (iii) large households; and (iv) those with a female head. Contribution, however, does not mean causality. The

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<sup>23</sup> The way incentives are designed play an important role in mitigating rent seeking. Community Driven Development Projects are particularly concern with elite capture even within poor communities.

idea of the analysis is to identify what types of households seem particularly excluded from the way access has increased so far. At the country level, location and education together are the main explanatory factors. Location (which is actually a slightly stronger influence) seems obvious, but education does not – unless it is linked to income poverty and remoteness of household location (even among rural areas). At the Indian state level, education actually starts to become a bigger factor than at the country level. And while the contribution of gender as the household head seems negligible at the country level, there are a number of Indian states (and districts within them) where access is clearly biased toward male-headed households.

**Policy choices should be aimed at increased shared prosperity.** In effect, the widespread equality in the access to improved water and to a lesser extent improved sanitation may also reflect a policy choice. The expansion of water provision is a direct benefit to households and providing water serves both politicians and households well. This does not mean that rent-seeking opportunities are not present or prevalent. Because of the widespread need to expand water services across income quintiles, improved water may hide rent-seeking opportunities especially in tariff structures and different forms of explicit and implicit subsidies. Adequate access to improved water may also reflect geography, as implied by our maps on improved water access – that is, lagging states in India that happen to coincide with the presence of ample water sources. Alternatively, geography may be an insurmountable obstacle, as in the case of connective infrastructures in mountainous countries like Bhutan and Nepal. But if a poorer country or a poorer state can have better access to a given infrastructure service than in a richer country or a richer state, then there is hope that policy makers can adopt measures that will improve access in a manner that increases shared prosperity.

**Infrastructure investments are no substitute for an incomes policy if the policy maker's objective is some sort of income redistribution.** Yet, they are effective ways of empowering households either directly via innovative mechanisms of decision making and implementation or indirectly via welfare improvements as in the “principle of inclusion” or through promoting economic growth as in the “principle of connectivity” (Biller and Nabi 2013). Policy makers should be cognizant ex ante that because of the importance of infrastructure services in economic growth, poverty reduction, and improving quality of life, interventions in infrastructure services provision will likely generate some perverse incentives regardless of the income quintiles that individual households belong to.

**If shared prosperity is one of the ultimate goals of policy makers, it is important to get accurate infrastructure data.** The analysis was constrained by the availability of data. The existing data allowed for a broad spatial analysis in physical terms and across time looking at the impact on different generations. It created a baseline for tracking progress in closing the infrastructure gap and on equality of opportunities across the region. It can be expanded and improved by considering more or less (opportunity and access) circumstances, exploring alternative indicators of access, and use and quality of infrastructure services. Yet, as specific economic questions were asked, the availability of consistent data across the board became scarcer. At different stages of the analysis, this constraint became more binding, restricting the number of countries and/or infrastructure sectors that could be studied. Some of the apparent inconsistencies in the data can only be clarified by in-depth field research. Without it, private and public investments may miss their targets of leveling the playing field and end up increasing inequality of infrastructure service provision.

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## Appendix A: Infrastructure Definition

In order to have a comparable definition of access to infrastructure we will use:

- a. Improved Water: The definition of access to water is based on the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. This definition is based on differentiating the water sources that by nature or intervention are protected from outside contamination. In Table A.1 we can see how sources of water can be divided between improved and unimproved water.

**Table A.1: Improved Water Classification**

Improved Water	Unimproved Water
Piped water into dwelling	Unprotected spring
Piped water to yard/plot	Unprotected dug well
Public tap or standpipe	Cart with small tank/drum
Tube well or borehole	Tanker-truck
Protected dug well	Surface water
Protected spring	Bottled water
Rainwater	

Source: WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation

- b. Improved Sanitation: The definition of access to sanitation is based on the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation. This definition is based on the classification among sanitation facilities that hygienically separate human excreta from human

contact, and it is for private use of the household. We can see in Table A.2 how to discriminate between facilities following JMP criteria for having a comparable sanitation infrastructure among countries of the region.

**Table A.2: Improved Sanitation Classification**

Improved Sanitation	Unimproved Sanitation
Private flush toilet	All shared facilities
Private piped sewer system	Flush/pour flush to elsewhere
Private septic tank	Pit latrine without slab
Private flush/pour flush to pit latrine	Bucket
Private ventilated improved pit latrine (VIP)	Hanging toilet or hanging latrine
Private pit latrine with slab	No facilities or bush or field
Private composting toilet	

Source: WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation

- c. Electricity: A household with access to electricity is defined by asking the household which is the principal way of lighting the house.
- d. Phone: The definition of having access to phone includes two types of technologies: landlines and mobile phones.
- e. Cooking Gas: Bottled cooking gas – liquefied petroleum gas (LPG).



## Appendix B: Data

**Different data sources were used in the analysis.** These sources are listed in table B.1. To be part of the analysis on regressivity, each survey needs to satisfy two conditions: a.) Contain reliable information on most infrastructure services namely, improved sanitation, improved water, electricity, telephones, and cooking gas; and b.) Contain a sample design representative at the smallest administrative region in a given country. The infrastructure services chosen for detailed analysis needs to be comparable across countries (see Appendix A for details). Table B.1-Panel A lists all surveys with information on the infrastructure services and their level of representativeness.

**On the poverty side, the analysis requires information about an income measure to estimate the poverty rate for each administrative region.** Table B.1-Panel B displays a great level of country attrition. The lack of income measure at lower levels of representativeness restricts the analysis of regressivity primarily to India, Sri Lanka, and Afghanistan.<sup>24</sup> More in-depth analysis is feasible only for the latter two countries.

**Table B1: The Surveys**

Country	Survey	Year	Representativeness Level
<b>Panel A: Infrastructure Data Sources</b>			
Afghanistan	National Risk and Vulnerability Assessment	2008	Province
Bangladesh	Multiple Indicator Cluster Survey	2006	District
Bhutan	Living Standard Measurement Study	2007	District
India	District Level Household Survey	2007	District
Maldives	Demographic Health Survey	2009	Region
Nepal	Demographic Health Survey	2011	Ecological zones
Pakistan	Demographic Health Survey	2006	Province
Sri Lanka	Household Income and Expenditure Survey	2010	District
<b>Panel B: Poverty Rates Data Sources</b>			
Afghanistan	National Risk and Vulnerability Assessment	2008	Province
Bangladesh			
Bhutan	Living Standard Measurement Study	2007	District
India	Debroy and Bhandari (2003) using NSS	2007	District
Maldives	-	-	-
Nepal	-	-	-
Pakistan	-	-	-
Sri Lanka	Household Income and Expenditure Survey	2010	District

<sup>24</sup> Bhutan was excluded from the analysis due to data inconsistencies.

## Appendix C: Infrastructure Index

The idea of creating an infrastructure index is to be able to have a measure of average access.

The process followed to create the three indexes were:

1. For each type of infrastructure estimate in which the quartile of access is the administrative region, we use the quartiles instead of the rate of access because we try to see a relation between income differences and a relative position inside the country.
2. The first index is constructed as an equally weighted average of the quartiles.
3. The second index is constructed with an importance-weighted average. The weights used are 0.39 for improved water, 0.28 for improved sanitation, 0.33 for electricity, and zero for cooking gas and phone. These weights are selected to have a measure only for the principal basic need of the household.
4. The weights for the third index are created based on the data using a Principal Component Analysis (PCA). Using the elements of the first component eigenvector (the principal component that maximizes the variance of the score) we create a weight for each type of infrastructure.

For the colors in the three-dimensional maps, three scores were constructed. Score I: Simple average (sum of the points for each indicator divided by the number of indicators); Score II: Weighted average using predetermined weights to capture that WATSAN and Power are important direct benefits to households; and Score III: Weighted average using weights obtained from a Principal Component Analysis – a statistical procedure. They all yield similar results. Each district is then ranked between 1 and 4. This ranking is dependent on the quartile the aggregate scores fall into. If a district falls in the bottom quartile it ranks 1 (red in the map, which indicates poor accessibility to infrastructure, while a district that scores in the top quartile ranks 4 (gold in the map), which indicates highest accessibility.