IGC

Sewers and urbanisation in developing countries: The case of Brazil

Sean McCulloch, Matthew Schaelling, Matthew Turner and Toru Kitagawa

- This study finds that providing sewer access to an extra 1% of neighbourhood households increases neighbourhood population density by about 6%.
- Changes in neighbourhood sewer access do not have significant effects on neighbourhood mean income or literacy rate.
- Improved sewer access benefits people with demographic characteristics like those of incumbent residents.
- The effect of sewer access on urban form and density is about as important as large transportation infrastructure projects.
- Rural residents can often double or triple their incomes by moving to the city, and peripheral urban residents can often increase their incomes by moving closer to the centre of the city.
- By making higher residential densities tolerable, sewers can permit more people to access high-wage urban jobs.
- Decisions about sewer expansions should consider these benefits in addition to the public health benefits of sewers.

POLICY BRIEF XXX-23154

MAY 2025

This policy brief forms part of a series on sewers and urbanisation in developing countries, with case studies of Brazil, Colombia, Tanzania, Jordan, and South Africa. Go to Sewers and informal settlements in cities in developing countries to find the same methodology applied to these different country contexts.

This project was funded by the IGC

theigc.org

DIRECTED BY

LSE

UNIVERSITY OF OXFORD

FUNDED BY

UKaid from the British people

Sewers and urbanisation

In many developing countries, rural residents can double or triple their incomes by moving to cities. Within cities in developing countries, people often realise large increases in their income by moving closer to the city centre, where higher-paying formal sector jobs are available. And yet, the urban share of the population in many developing countries is below that of more developed countries. This invites us to ask why cities in developing countries are not growing even faster.

One possibility is that cities in developing countries are so polluted and congested that doubling or tripling income is insufficient to compensate for the forgone pleasures of rural life. Indeed, according to the World Bank, about one-third of the residents of cities in developing countries lack access to even rudimentary sanitation facilities, and about the same share live in informal settlements. Given the high densities common in cities in developing countries, it requires only a little imagination to see why people might rather stay in the countryside.

Our research asks whether improving access to residential sanitary sewers can allow cities in developing countries to accommodate more people by making higher population densities more tolerable. By extension, we are asking whether improving access to sanitary sewers can facilitate the movement of people from the countryside or urban periphery to more productive central city employment.

We find that people are willing to live at much higher densities in neighbourhoods with sewer access than without. Providing sewer access for an extra 1% of neighbourhood households causes about a 6% increase in neighbourhood population density. We also find that sewers cause this increase in population density without precipitating an influx of wealthier, better-educated migrants. Thus, improving sewer service in low-income neighbourhoods probably enhances the lives of people with low incomes, rather than leading to their displacement from their homes.

Do sewers actually cause neighbourhoods to change?

We investigate the effects of sewer access on neighbourhood population density, literacy, and mean income in a sample of 92 cities in the following developing countries: Brazil, Colombia, South Africa, Tanzania, and Jordan.

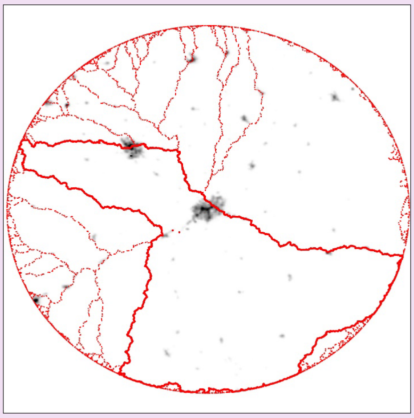
No sensible policymaker would sewer undevelopable land, and sufficiently high population densities cannot occur without sewers. Thus, simply comparing the population density in places with sewers to places without is probably not informative. Such a comparison compounds the fact that places that receive sewer service differ from those that do not, with whatever changes follow from sewer construction.

To resolve this problem, we compare neighbourhoods on opposite sides of drainage basin divides. To understand why this comparison is informative, note that a drainage basin is defined as an area within which all rainfall (or sewage) drains to the same point. Figure 1 illustrates the drainage basins around Cascavel, Brazil.

From this definition of a drainage basin, it is clear that water and sewage must flow away from the boundary of a drainage basin divide; divides are local high spots. But this means that sewage outside a drainage basin with sewer service must travel uphill to cross the divide and reach a central sewer network. This is not easy to accomplish, so crossing a drainage basin divide increases the cost of sewer service and decreases its availability. Figure 2 illustrates sewer access in a neighbourhood of Cascavel, Brazil, along with basin divides. This figure clearly shows how a decrease in sewer access occurs when crossing from the drainage basin that contains central Cascavel and its sewer system to an adjacent drainage basin.

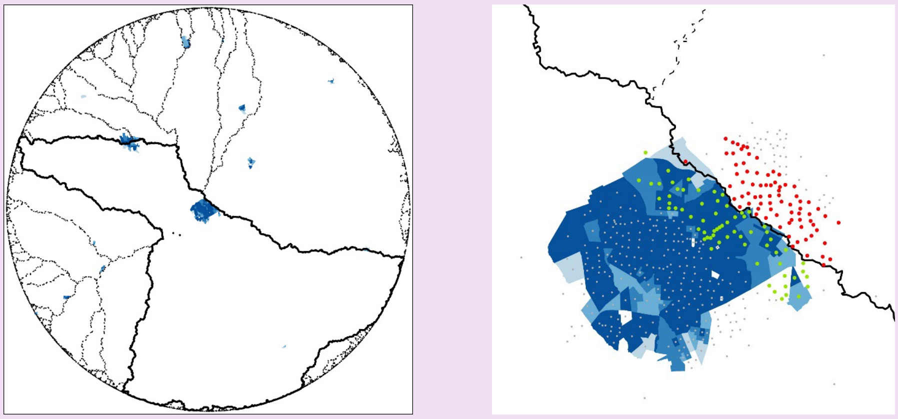
Even though drainage basin divides are important for sewer construction, they are usually such minor landscape features that they are almost unnoticeable. Thus, if we see population differences across basin divides, we can be confident that they exist because of differences in sewer access. Hence, our strategy is to compare population density and other outcomes for nearby neighbourhoods on opposite sides of a basin divide.

FIGURE 1: Drainage basins and lights at night around Cascavel, Brazil



Note: Dashed red lines indicate drainage basin boundaries around Cascavel, Brazil. Lights at night show city extent. The disk has a radius of 75 km.

FIGURE 2: Drainage basins and sewer access around Cascavel, Brazil



Note: The left panel describes the same region as in Figure 1. The right panel is a close-up. Darker blue indicates a larger share of households with sewer access. Dots indicate the centres of neighbourhoods in our sample.

How important are sewers for urban density?

We estimate that providing sewer access to an additional 1% of households in a census tract causes an increase in tract population density of about 6%. We conduct two exercises to assess how important this effect is.

In the first, we provide sewer access to an additional 1% of households living in the densest parts of the city, and then ask how much this increases the density around an average resident. This effect is almost the same as the negative effect of a single radial highway on an average US city.

In the second exercise, we imagine providing universal sewer access to all neighbourhoods within walking distance (4 km) of the city centre. The resulting increase in central population means that, in many cities, about the same share of city population gains walking access to the central city as gained access to central Bogota because of the Transmilenio BRT system, one of the most successful BRT systems in the world.

That is, in many developing world cities, providing sewer access to a small fraction of households is often as important for how the city is organised as a big improvement to transportation infrastructure.

Sewers and the organisation of Brazilian cities

Investments in more extensive sewer networks are almost surely beneficial, but they preclude other investments. Hence, the decision to invest in sewers must rest on whether such investments contribute more to public welfare than the alternatives. Here, we attempt to use our results, together with results in the literature, to provide a foundation for comparing investments in sewers to alternatives like improved roads, transit, electric service, or schools, on a city-by-city basis.

There is evidence that sewers, particularly in combination with better water supplies, reduce infant mortality. Alsan and Goldin (2019) find that water and sewer access reduced infant mortality by about 25%, and Bhalotra (2021) finds that chlorination of drinking water reduced infant mortality by 45% or more. However, Gamper-Rabindram et al. (2010) and Anderson et al. (2018) find much smaller effects from similar interventions. In all, there is a good case for expecting dramatic improvements in public health to follow from improved sewer access. For the purposes of cost-benefit analysis, one can convert the benefits of such averted mortality to dollars using the values in, for example, Viscusi and Aldy (2003).

Beyond their effect on public health, our results demonstrate that sewer access leads to much higher urban densities. These higher densities have three implications for the value of improved sewer access.

First, by increasing density, sewers increase the number of people who can live in the city and work in urban jobs. If the new people would otherwise have lived in the city, their urban migration often involves a doubling of income (Henderson and Turner, 2020). These increases in income can be counted as benefits of sewer expansion.

Second, the density of cities causes people to be more productive. A central estimate of this effect is that labour productivity (i.e., wages) increases by about 0.5% for every 10% increase in population density. This effect operates on all residents, not just marginal new residents, so it can often be a large amount. Such increases in income can also be counted as benefits of sewer expansion.

Third, higher-paying, formal sector jobs tend to be located in the centre of the city, and one of the arguments for improved roads and public transit is to improve access to centrally located formal sector jobs. To the extent that central residential areas are not completely sewered, improvements in central sewer access can serve much the same purpose. By increasing population density within walking distance of the city centre, sewer networks increase access to central jobs, just as transit infrastructure does. The resulting increased wages and tax receipts can be counted as benefits of improved sewer access.

In practice, the benefits of improvements to the sewer network will vary with the extent of the existing network and with the population density of sewered and unsewered areas in each city. Using our data and results, we can calculate the effects of small hypothetical improvements to the sewer network to help inform these calculations.

To estimate the effects of sewer expansions on Brazilian cities, we perform the two exercises described in the previous section for each of the 56 Brazilian cities in our data. Table 1 reports results and provides some descriptive statistics.

Column 1 gives the name of the city, and column 2 lists its population as reported by the UN in 2014. In column 3, we report the share of people in the city who live in the drainage basin containing the city centre. In the first row, we see that the population of Anapolis is about 350,000 (in 2014) and that the whole population of the city is in the central drainage basin. Looking down column 3, we see that this is often not the case, particularly in larger cities. The remaining columns describe our calculations to assess the importance of sewers.

For our first exercise, we add 1% of city households to the sewer network, starting with the households in the densest tracts with unsewered households. Column 4 reports the share of households in the city's central basin reporting that they have sewer access. Column 5 reports the initial population density in the census tract inhabited by an average resident of the central basin. Column 6 reports the share by which this density increases when we add 1% of city households to the sewer network.

For example, Anapolis has a population of about 350,000, so we add about 3,500 households to the sewer network in the central basin. The initial population density of the census tract inhabited by an average central basin resident is 4,649 per square km. Applying our 6% estimated effect to treated areas gives a 16% increase in this density from the base of 4,649. For the purpose of evaluating agglomeration economies, this is the relevant increase in density. Looking down column 6, we see a range of estimates from as low as 5% to above 30%, depending on the location and population density of the newly sewered households. This variation implies variation in the benefits of agglomeration that follow from this plan for sewer construction.

For our second exercise, we provide universal sewer access to all households within 4 km of the CBD (central business district) and calculate the resulting increase in the central population.

Column 7 reports the share of the total city population (from column 2) living within 4 km of the city centre. Column 8 reports the share of these central city residents who report sewer access. Column 9 reports the counterfactual increase in the share of the population in this central area if sewer access were made universal. Because the size of the central area is fixed, the implied increase in density is what is relevant for the calculation of agglomeration effects.

Again, using Anapolis as an example, we see in column 7 that 49% of the population lives within 4 km of the city centre. In column 8, we see that 67% of these central city residents report sewer access. In column 9, we calculate that the counterfactual central population increases by 96% of the population of the whole city (from column 2). Note that the interpretation of column 9 is particular. Initially, 49% of the city population lives within the 4 km central disk. After the intervention, the population of this central area increases by 96% of the whole city population. From this, we calculate that the population of the central area increases by a factor of (0.49+0.96)/0.49, or just less than a factor of three. For the central region of Anapolis, we would evaluate agglomeration benefits on the basis of a near tripling of the central population and density.

Looking down column 9, we see dramatic variation in the magnitude of this effect. The effect is small in large cities where the central area has high rates of initial sewer access. On the other hand, in cities where the central 4 km disk houses a larger share of the initial population and is largely unsewered, the effect is much larger.

Conclusion and takeaways

Cities in developing countries often face a portfolio of problems. Schools, roads, transit, and electricity services may all be inadequate and maintaining tax rolls and law enforcement is difficult. The weight of evidence suggests that sanitary sewers will often cause dramatic improvements in public health and reductions in infant mortality. Our results mean that their benefits are even larger. They allow cities to accommodate many more people and access high-paying urban jobs. These results should lead policymakers to revise upwards the priority given to the provision of residential sanitary sewers.

References

Viscusi, W. K., & Aldy, J. E. (2003). The value of a statistical life: A critical review of market estimates throughout the world. *Journal of Risk and Uncertainty, 27*(1), 5–76.

Alsan, M., & Goldin, C. (2019). Watersheds in child mortality: The role of effective water and sewerage infrastructure, 1880–1920. *Journal of Political Economy, 127*(2), 586–638.

Anderson, D. M., Charles, K. K., & Rees, D. I. (2018). Public health efforts and the decline in urban mortality (Technical Report). *National Bureau of Economic Research.*

Bhalotra, S. R., Diaz-Cayeros, A., Miller, G., Miranda, A., & Venkataramani, A. S. (2021). Urban water disinfection and mortality decline in lower-income countries. *American Economic Journal: Economic Policy, 13*(4), 490–520.

Gamper-Rabindran, S., Khan, S., & Timmins, C. (2010). The impact of piped water provision on infant mortality in Brazil: A quantile panel data approach. *Journal of Development Economics, 92*(2), 188–200.

Henderson, J. V., & Turner, M. A. (2020). Urbanization in the developing world: Too early or too slow? *Journal of Economic Perspectives, 34*(3), 150–173

Appendix

TABLE 1: Estimated effects of sewers on Brazilian cities

(1) City	(2) Population	(3) Share of pop. living in central basin	(4) Share sewered in central basin	(5) Initial experienced population density	(6) Change in population density if 1% increase in sewer access	(7) Share of total pop. living within 4km of CBD	(8) Share sewered within 4km of CBD	(9) Population growth in 4km of CBD if universal sewer access
Anapolis	350,737	1.00	0.42	4,649	0.16	0.49	0.67	0.96
Aracaju	889,202	0.57	0.69	12,400	0.17	0.40	0.82	0.42
Bauru	353,372	1.00	0.96	5,430	0.07	0.51	0.98	0.05
Belem	2,147,707	0.35	0.45	20,112	0.17	0.27	0.52	0.78
Belo Horizonte	5,683,651	0.71	0.88	12,191	0.12	0.10	0.98	0.01
Blumenau	315,547	1.00	0.27	3,332	0.47	0.28	0.36	1.08
Brasilia	4,072,397	0.43	0.69	10,816	0.16	0.03	0.98	0.00
Campina Grande	380,578	1.00	0.80	9,351	0.14	0.65	0.89	0.44
Campinas	2,994,328	1.00	0.82	8,801	0.16	0.10	0.94	0.03
Campo Grande	823,949	0.88	0.45	4,960	0.16	0.20	0.79	0.25
Campos dos Goytacazes	432,135	0.68	0.54	8,454	0.30	0.43	0.74	0.67
Caruaru	299,752	1.00	0.77	11,687	0.26	0.84	0.85	0.75
Cascavel	287,467	1.00	0.57	4,320	0.12	0.52	0.67	1.00
Caxias Do Sul	444,884	1.00	0.77	7,488	0.34	0.55	0.84	0.53
Cuiaba	566,787	1.00	0.53	6,345	0.19	0.33	0.72	0.54
Curitiba	3,341,428	0.90	0.77	7,825	0.15	0.09	0.96	0.02
Feira De Santana	546,469	1.00	0.43	7,670	0.19	0.52	0.68	1.00
Florianopolis	1,100,126	0.14	0.81	15,974	0.14	0.13	0.88	0.10
Fortaleza	3,742,260	0.43	0.54	14,778	0.40	0.12	0.91	0.06
Franca	328,655	1.00	0.95	5,955	0.04	0.49	0.99	0.02
Goiania	2,291,895	0.88	0.50	6,659	0.14	0.12	0.96	0.03
Vale do Aco	493,378	1.00	0.98	18,715	0.09	0.92	0.98	0.10
Joao Pessoa	1,269,780	0.24	0.69	9,801	0.19	0.19	0.78	0.24
Joinville	1,189,481	0.29	0.34	4,810	0.40	0.12	0.50	0.35
Juazeiro Do Norte	410,833	1.00	0.32	10,115	0.20	0.50	0.40	1.78
Juiz De Fora	536,469	1.00	0.91	9,987	0.08	0.57	0.96	0.12
Jundiai	609,980	1.00	0.85	11,545	0.31	0.31	0.98	0.03
Londrina	792,447	1.00	0.69	6,070	0.14	0.27	0.92	0.11
Macapa	421,092	0.69	0.11	9,706	0.32	0.46	0.17	2.29

Maceio	1,222,564	0.29	0.44	18,559	0.17	0.27	0.47	0.86
Maringa	377,035	1.00	0.71	6,935	0.10	0.48	0.90	0.27
Montes Claros	365,545	1.00	0.90	7,523	0.09	0.71	0.98	0.10
Natal	1,259,108	0.20	0.69	12,562	0.15	0.19	0.73	0.29
Pelotas	314,612	0.78	0.63	9,084	0.30	0.49	0.78	0.66
Piracicaba	374,548	1.00	0.96	8,015	0.05	0.53	0.98	0.04
Ponta Grossa	322,455	1.00	0.76	4,168	0.13	0.48	0.84	0.46
Porto Alegre	3,966,450	0.15	0.85	16,347	0.12	0.07	0.96	0.02
Recife	3,785,339	0.48	0.46	13,896	0.23	0.15	0.69	0.28
Ribeirao Preto	643,613	1.00	0.96	9,874	0.11	0.43	0.98	0.05
Rio Branco	332,480	1.00	0.44	4,934	0.17	0.57	0.55	1.54
Rio de Janeiro	12,825,373	0.06	0.95	42,717	0.08	0.03	0.98	0.00
Salvador	3,542,497	0.30	0.95	33,350	0.09	0.15	0.97	0.03
Baixada Santista	1,755,103	0.15	0.85	21,517	0.17	0.13	0.90	0.08
Sao Jose do Rio Preto	405,556	1.00	0.94	6,784	0.05	0.46	0.99	0.03
Sao Jose dos Campos	652,912	1.00	0.91	11,181	0.09	0.23	0.96	0.05
Grande Sao Luis	1,393,492	0.41	0.51	12,089	0.21	0.14	0.65	0.30
Sao Paulo	20,633,309	0.93	0.87	29,556	0.21	0.03	0.97	0.01
Sorocaba	717,571	1.00	0.93	7,819	0.13	0.34	0.98	0.04
Taubate	288,534	1.00	0.95	7,902	0.07	0.74	0.97	0.11
Teresina	949,091	1.00	0.16	8,027	0.23	0.22	0.40	0.80
Uberaba	306,844	0.92	0.92	5,910	0.07	0.67	0.98	0.08
Uberlandia	625,735	1.00	0.95	6,366	0.07	0.39	0.99	0.02
Grande Vitoria	1,836,918	0.15	0.84	15,778	0.21	0.14	0.90	0.09
Vitoria da Conquista	295,364	1.00	0.52	7,675	0.15	0.66	0.71	1.15
Volta Redonda	438,521	1.00	0.90	8,021	0.13	0.39	0.94	0.13