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FUNCTIONAL CITIES, ADMINISTRATIVE BOUNDARIES: METROPOLITAN INFRASTRUCTURE AND THE COST OF FRAGMENTATION

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ABSTRACT

Cities are functional systems defined by commuting, water catchments and waste flows, while the authorities that plan and fund their infrastructure are defined by administrative lines drawn for other purposes. This study examines the consequences of that divergence and what follows for infrastructure design. The method is a structured review of research published between 2017 and 2024 combined with a synthesis of published quantities on urban expansion, fragmentation and cooperation. Three findings follow. The functional city is now the majority setting: a global delineation identifies 8,790 functional urban areas containing roughly 3.9 billion people, some 53 per cent of the world population, and across 363 million-plus cities urban land expanded at 1.08 per cent annually between 1970 and 2014 while the influence of economic growth on that expansion rose markedly after 2000. Growth has moved outward: in one Indonesian conurbation corridor urban land rose from 10.26 to 22.27 per cent of area between 2000 and 2020, while in another metropolitan region the primary city was relatively stagnant and development intensified in secondary cities. And fragmentation is costly, with fragmented metropolitan governance associated with lower productivity by an amount its authors describe as at least as important as the benefit of city size. The study argues that the operative design question is not whether jurisdictions should cooperate but which functions should be delegated upward, since the cooperation evidence indicates savings arise specifically where delegation to a higher tier occurs.

ABSTRAK

Kota adalah sistem fungsional yang dibatasi oleh pola komuter, daerah tangkapan air, dan aliran sampah, sementara otoritas yang merencanakan dan membiayai infrastrukturnya dibatasi oleh garis administratif yang ditarik untuk maksud lain. Penelitian ini menelaah akibat dari perbedaan itu dan implikasinya bagi desain infrastruktur. Metodenya adalah telaah terstruktur riset terbitan 2017 hingga 2024 yang dipadukan dengan sintesis angka terpublikasi mengenai perluasan kota, fragmentasi, dan kerja sama. Tiga temuan mengikutinya. Kota fungsional kini merupakan latar mayoritas: satu delineasi global mengidentifikasi 8.790 wilayah perkotaan fungsional yang menampung sekitar 3,9 miliar orang, sekitar 53 persen penduduk dunia, dan pada 363 kota berpenduduk di atas satu juta lahan perkotaan meluas 1,08 persen per tahun sepanjang 1970 hingga 2014, dengan pengaruh pertumbuhan ekonomi atas perluasan itu meningkat tajam setelah tahun 2000. Pertumbuhannya bergerak ke luar: pada satu koridor konurbasi di Indonesia lahan perkotaan naik dari 10,26 menjadi 22,27 persen luas wilayah antara 2000 dan 2020, sedangkan pada kawasan metropolitan lain kota intinya relatif stagnan sementara pembangunan justru menguat di kota-kota sekunder. Fragmentasi pun mahal: tata kelola

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metropolitan yang terfragmentasi berasosiasi dengan produktivitas lebih rendah sebesar yang oleh penulisnya disebut setidaknya sama pentingnya dengan manfaat ukuran kota. Penelitian ini berargumen bahwa pertanyaan desain yang sesungguhnya bukanlah apakah daerah harus bekerja sama, melainkan fungsi mana yang harus didelegasikan ke atas, karena bukti mengenai kerja sama menunjukkan penghematan muncul justru ketika terjadi pendelegasian ke tingkat pemerintahan yang lebih tinggi.
Kata kunci: wilayah perkotaan fungsional; tata kelola metropolitan; koordinasi infrastruktur; perluasan kota; kerja sama antardaerah

1. INTRODUCTION

A city is where people live, work and travel between the two. A municipality is a legal person with a boundary. These were once approximately the same thing, and in most of the world they no longer are. The commute crosses the line; so do the water main, the drainage basin, the landfill traffic and the bus route. The plan and the budget do not.

This divergence is not a defect of any particular administration. It is what happens when a settlement grows faster than the institutions drawn around it, which is the normal condition of urbanisation. What makes it an engineering and infrastructure problem rather than only a political one is that infrastructure is sized, sited and financed at the scale of the authority commissioning it. A treatment plant designed for a district's projected population is correctly sized for that district and incorrectly sized for the catchment it actually serves.

The measurement of this gap has improved considerably. Moreno-Monroy et al. (2021) construct a global delineation of functional urban areas from gridded density and travel-impedance data rather than from commuting surveys that do not exist for most countries, identifying 8,790 such areas containing approximately 3.9 billion people, some 53 per cent of the world population, and finding that between 2000 and 2015 commuting zones grew faster than urban cores. The functional city is now measurable at global scale, and it is not the administrative city.

Indonesia's metropolitan regions exhibit the pattern in a form that is unusually well documented. Firman and Fahmi (2017) find the fringe of the Jakarta metropolitan region transformed from dormitory settlements into independent towns through private industrial estate and new town development, attributing this jointly to pro-growth national policy and to the autonomy granted to fringe municipalities. Jatayu et al. (2023) attribute the growth pattern of one conurbation corridor explicitly to the misalignment of planning policies among the municipalities composing it.

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Three questions organise the study. First, what do the measurements establish about the size, direction and drivers of the gap between functional and administrative urban geography? Second, what does the evidence establish about the cost of governing that geography through fragmented jurisdictions? Third, given that evidence, what should be coordinated, what should be delegated, and to which tier?

2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Measuring the functional city

Moreno-Monroy et al. (2021) delineate functional urban areas as high-density urban centres of at least fifty thousand people together with their commuting zones, using morphological analysis combined with travel impedance. Their two results matter separately: the count and population establish that functional urban areas are the majority human settlement form, and the finding that commuting zones grew faster than cores between 2000 and 2015 establishes that the gap between functional and administrative geography is widening rather than closing.

Dijkstra et al. (2021) apply the Degree of Urbanisation classification globally and find that it yields urban population shares similar to national definitions in the Americas, Europe and Oceania but considerably higher in Africa and Asia, because places that function as towns or cities are classified rural under national definitions. They also report that the share of land covered by cities and the number of cities have both doubled over four decades, with city population growing faster than city area so that densities rose. The implication for infrastructure planning in Asia is direct: national statistical classifications understate the urban population that infrastructure must serve.

Mahtta et al. (2022) quantify the drivers. Across 363 million-plus cities between 1970 and 2014, mean annual urban land expansion was 1.08 per cent against mean annual population growth of 1.58 per cent and mean annual growth in gross domestic product per capita of 4.21 per cent. Population growth is consistently the dominant determinant, but the influence of economic growth rises markedly after 2000: a one-unit increase in population growth was associated with 16 per cent more expansion before 2000 and 23 per cent after, while for income growth the corresponding figures were 7.3 and 12.4 per cent. They also find that in countries with strong governance, economic growth contributes more to expansion than population growth does.

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The cost of fragmentation

Ahrend et al. (2017) combine cross-country estimates of agglomeration benefits with the productivity effect of metropolitan governance structures, using an internationally harmonised city definition based on economic linkages rather than administrative boundaries and controlling for the sorting of individuals across cities. City productivity rises with city size, but cities with fragmented governance structures are less productive, and the effect is mitigated where a metropolitan governance body exists. The authors state that the governance penalty is at least as important as the agglomeration benefit associated with city size — a comparison that places institutional design on the same footing as scale.

Goodman (2019) supplies the conceptual apparatus, separating horizontal fragmentation, meaning many governments at the same tier, from vertical fragmentation, meaning overlapping tiers and special districts, and reviewing the empirical evidence on expenditure, employment and growth outcomes. The distinction matters for design because the two forms admit different remedies: horizontal fragmentation invites cooperation or amalgamation, vertical fragmentation invites consolidation of overlapping mandates.

Kübler and Rochat (2019), analysing social expenditure across 630 municipalities in seven Swiss metropolitan areas, ask whether intergovernmental cooperation and revenue sharing can redress spatial equity in fragmented metros, moving past the deadlock between consolidation and polycentric advocacy. Their finding is measured: intergovernmental grants make a significant but limited contribution to reducing the mismatch between needs and resources, and how much they contribute depends on redistributive effort by higher tiers of the state.

Cooperation and its conditions

Bel and Sebő (2021) address the question directly through a meta-regression reconciling the contradictory empirical literature on whether intermunicipal cooperation reduces service delivery costs. They find no clear evidence that transaction costs explain the divergence between studies, but strong evidence that population size and governance form do: small populations and delegation to a higher tier of government deliver the cost advantages. This is the single most consequential result for the present argument, because it distinguishes cooperation as an aspiration from delegation as a mechanism.

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Tavares and Feiock (2018) provide the design vocabulary, extending the institutional collective action framework to Europe and constructing a typology on two dimensions — the type of urban integration mechanism, comprising imposed authority, delegated authority, contracts and social embeddedness, and institutional scope, narrow through complex — yielding twelve arrangement types. Moore-Cherry et al. (2022), reviewing English-language literature from 2014 to 2019, find broad agreement that the metropolitan scale is the appropriate one for coordinated land management and no agreement on the mechanisms to deliver it, concluding that steering metropolitanisation through formal structures will require significant adaptation in power and funding structures.

Leon-Moreta and Totaro (2023), examining municipal water and wastewater expenditure across United States city-regions from 2002 to 2017, find spending linked to interactions between adjacent cities and to changes in jurisdictional boundaries, which is direct evidence that these particular networks are governed as if bounded when they are not. Biswas (2020) examines India's constitutional provision for metropolitan development authorities alongside autonomous urban local bodies, showing how metropolitan institutions can integrate decentralised governments while documenting wide implementation variation across states.

Agglomeration and density

Duranton and Puga (2020) set out the underlying economics: density raises productivity and innovation, improves access to goods and services, shortens travel distances and favours energy-efficient construction and transport, while simultaneously constituting crowding and raising the cost of living and moving. Density is both cause and consequence of how cities evolve, and the trade-off is resolved imperfectly by market and political forces alike. The relevance here is that the benefits accrue at the scale of the functional city while the costs are borne, and the mitigating infrastructure provided, at the scale of the jurisdiction.

Indonesian metropolitan evidence

Firman and Fahmi (2017) document the privatisation of the Jakarta metropolitan fringe, where industrial estates and new towns turned dormitory areas into independent towns under private land acquisition, development and management, driven jointly by national pro-growth policy and by municipal autonomy. Mulya et al. (2024) trace agricultural land and rural-urban transition across the same region from 2000 to 2019, finding conversion of second-class paddy fields as built-up land expanded between 2000 and 2011, and between

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2011 and 2019 massive change in peri-urban areas alongside low-intensity expansion in the city centre.

Pratama et al. (2022) identify the causal role of transport investment within the metropolitan area, using historic infrastructure as instrumental variables and finding that improved highway access increases urban sprawl within the region, concentrated in the band 40 to 50 kilometres from the centre. Jatayu et al. (2023), applying landscape metrics to a conurbation corridor of the Jakarta-Bandung mega-urban region, find urban land use rising from 10.26 per cent of corridor area in 2000 to 22.27 per cent in 2020 with predicted annual growth around one per cent, urban density rising while compactness falls, two urban areas converging into one another, and agriculture's contribution to regional product falling from above 50 per cent to about 34 per cent. They attribute the pattern to misalignment of planning policies among the corridor's municipalities.

Two further studies extend the evidence beyond Jakarta. Indrayati et al. (2024), analysing a Central Java metropolitan corridor from 2010 to 2020, find average built-up area change of 3.25 per cent, with the largest built-up area along one inter-city corridor, no correlation between built-up change and socioeconomic facilities, and urban change in the primary city relatively stagnant while more intensive development occurs in the secondary cities. Duriyyah and Rahmawati (2022), examining an East Java metropolitan area of seven jurisdictions from 2016 to 2019, find relatively high income inequality within the region, one regency classified as underdeveloped while six show rapid growth potential, and the strongest economic linkages running from two adjacent jurisdictions to the core city.

Fragmentation and the consumption of land

Beghelli et al. (2020) supply the quantified link between governance structure and spatial outcome that the productivity literature leaves implicit. Examining 180 cities across two continents over twelve years, they find that more fragmented governance increases inter-municipal competition for residents and business and raises land consumption, with the effect positive in both regions though differing in magnitude. Fragmentation, on this evidence, does not merely fail to coordinate infrastructure; it actively enlarges the area that infrastructure must serve.

Sahana et al. (2023), reviewing 3,124 publications of which 56 address the question directly, conclude that no generalised method exists for demarcating the peri-urban, with approaches varying by land use, socioeconomic condition and political system and framing differing

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sharply between higher- and lower-income settings. The finding qualifies the delineation literature relied on earlier in this study: functional urban areas can be delineated globally by consistent method, but the transitional zone where most growth occurs resists any single definition.

Modelling where the growth goes

Three studies establish that metropolitan expansion is projectable with standard remote-sensing methods, which matters because infrastructure sizing requires a forecast rather than a description. Mithun et al. (2022) compare three techniques for one metropolitan area and find a neural network approach performing best, with a Kappa coefficient of 0.9025, projecting built-up coverage rising from thirty-one per cent to fifty-five per cent across two decades. Their framing against the international indicator for land-use efficiency indicates how such projections connect to reporting obligations already in place.

Mahmoudzadeh et al. (2022) document expansion in another metropolitan region from 7,220 to 27,641 hectares across thirty-four years with agricultural and garden land falling by 8,514 hectares, and propose guiding roughly thirty per cent of future development to infill together with a green-belt network. Addae and Oppelt (2019) record a 277 per cent increase in built-up area across twenty-four years in a rapidly growing metropolitan area of the Global South, with forest cover falling from thirty-four to 6.5 per cent and urban coverage projected to reach seventy per cent.

Arifin et al. (2023) supply the Indonesian projection, modelling peri-urban land conversion around a coastal city and forecasting built-up land reaching 11,531.4 hectares, or 67.27 per cent of the study area, against 5,611.8 hectares of vacant land, for a projected population of approximately two million. Their recommendation is to modify coastal development strategy to preserve open space and enforce zoning — which is a planning instrument held at municipal level for a growth process that the same study shows crossing municipal boundaries.

Research gap

Three gaps shape this study. The measurement literature and the governance literature have developed largely separately, so what the improved delineation of functional urban areas implies for infrastructure institutions has not been stated. The verified evidence on the cost of cross-boundary infrastructure coordination is drawn from high-income settings, with no

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comparable verified study located for Southeast Asia. And no verified study within the review window addresses metropolitan infrastructure financing across boundaries as a subject in its own right; that theme is reached only obliquely through work on revenue sharing and delegation.

3. METHOD

The study is a structured review with a synthesis of published quantities. It generates no primary data, performs no spatial analysis, and offers no estimate of infrastructure requirements for any metropolitan region.

Source identification and verification

Peer-reviewed studies published between 2017 and 2024 on functional urban area delineation, urban land expansion, metropolitan governance and fragmentation, intermunicipal cooperation, cross-boundary infrastructure, and Indonesian metropolitan development were identified and retained only where bibliographic details could be verified against a publisher page, a digital object identifier record, an indexing database record or an institutional repository. Sources whose findings could not be read directly were excluded even where bibliographic details were confirmed. Journals whose indexing status had lapsed, and outlets identified as hijacked or without demonstrable peer review, were excluded.

Treatment of quantities

All quantities are reported as published from a single identified source and are not recalculated or combined. Where an author team has published quantified estimates in a non-peer-reviewed summary that could not be located within the peer-reviewed article itself, those figures are omitted and only the direction and the authors' own characterisation of magnitude are reported. This affects the fragmentation-productivity estimates specifically, and the omission is stated where it occurs.

Comparative use of national cases

Indonesian, Swiss, United States, Czech, Indian and global evidence is used for distinct purposes and not pooled. Indonesian studies supply the pattern of outward growth and jurisdictional misalignment; high-income studies supply the cost and productivity evidence,

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which is treated as indicative for other settings rather than transferable, since no equivalent Southeast Asian study was verified.

4. RESULTS AND DISCUSSION

The functional city is the majority setting

Table 1. Verified quantities on urban form and expansion

Quantity	Value	Source
Functional urban areas identified globally	8,790	Moreno-Monroy et al. (2021)
Population living in them	~3.9 billion (53% of world population)	Moreno-Monroy et al. (2021)
Relative growth, 2000-2015	Commuting zones grew faster than cores	Moreno-Monroy et al. (2021)
Change in land covered by cities over four decades	Doubled; number of cities also doubled	Dijkstra et al. (2021)
Mean annual urban land expansion, 363 cities 1970-2014	1.08 per cent	Mahtta et al. (2022)
Mean annual population growth, same sample	1.58 per cent	Mahtta et al. (2022)
Mean annual GDP per capita growth, same sample	4.21 per cent	Mahtta et al. (2022)
Projected global urban population growth to 2050	2.5 billion	Mahtta et al. (2022)

Source: compiled by the authors. Figures are reported as published and are not recalculated or combined across sources.

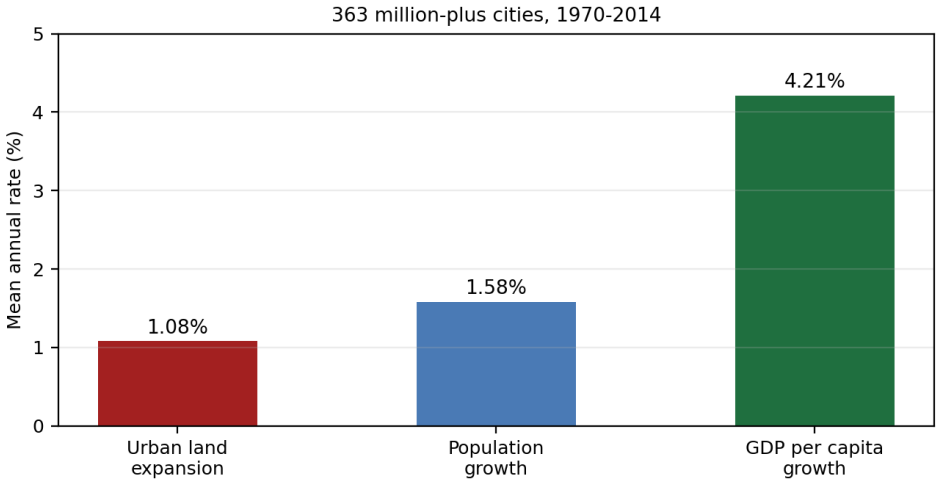


Figure 1. Mean annual rates of urban land expansion, population growth and income growth (source: Mahtta et al., 2022)

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Two features of Figure 1 govern what follows. Urban land expands more slowly than population, which means densification rather than pure sprawl is the dominant global pattern and is consistent with Dijkstra et al.'s (2021) finding that city population grew faster than city area. And income growth, at roughly four times the rate of land expansion, is the variable whose influence has risen: Mahtta et al. (2022) report the association between income growth and expansion strengthening from 7.3 to 12.4 per cent across the year 2000, against 16 to 23 per cent for population growth. Infrastructure planning calibrated to population projection alone is therefore calibrated to the weakening driver.

Dijkstra et al.'s (2021) finding that national definitions understate urban population in Asia and Africa has an operational consequence that is easy to overlook. Where a settlement is classified rural, it receives rural infrastructure standards, rural service norms and rural budget allocations, while functioning as a town. The classification is not merely descriptive; it determines what gets built.

Growth has moved outward and sideways

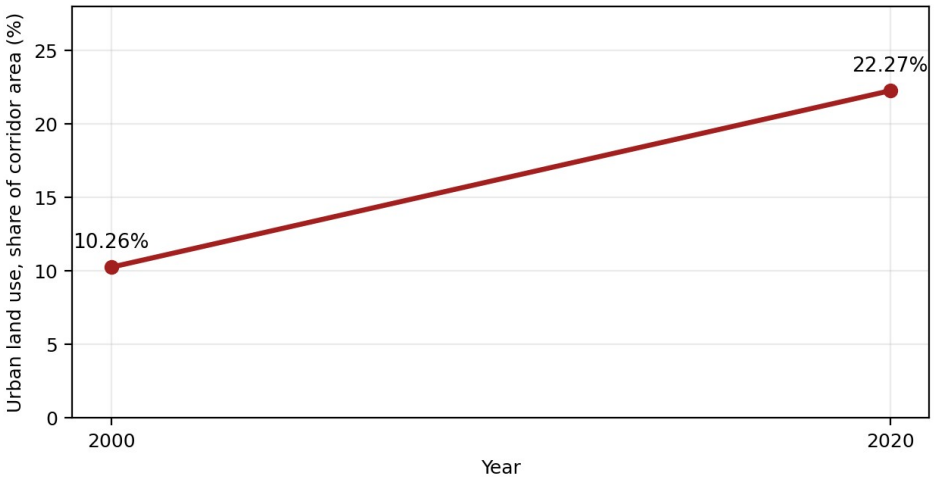


Figure 2. Urban land use as a share of corridor area, Jakarta-Bandung south conurbation corridor (source: Jatayu et al., 2023)

The Indonesian evidence describes a consistent spatial pattern across three metropolitan regions. In the Jakarta-Bandung corridor, urban land more than doubled as a share of area between 2000 and 2020, density rose while compactness fell, and two separate urban areas converged into one — a merger of settlements that no single municipality planned. In the wider Jakarta region, Mulya et al. (2024) find massive peri-urban change between 2011 and

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2019 alongside low-intensity expansion in the centre, and Pratama et al. (2022) identify highway access as a causal driver of sprawl concentrated 40 to 50 kilometres out.

Indrayati et al.'s (2024) Central Java result adds the complementary case: the primary city relatively stagnant while development intensifies in secondary cities. Taken with Duriyyah and Rahmawati's (2022) finding of high internal income inequality and one underdeveloped regency among seven jurisdictions in an East Java metropolitan area, the picture is of metropolitan regions whose growth and whose deprivation are both located away from the core.

Table 2. Spatial pattern of metropolitan growth in the Indonesian evidence

Region examined	Period	Finding	Source
Jakarta metropolitan fringe	to 2017	Fringe became independent towns via private estates and new towns	Firman & Fahmi (2017)
Greater Jakarta	2000-2019	Massive peri-urban change 2011-2019; low-intensity expansion in centre	Mulya et al. (2024)
Jakarta metropolitan area	three decades	Highway access increases sprawl, concentrated 40-50 km from centre	Pratama et al. (2022)
Jakarta-Bandung south corridor	2000-2020	Urban land 10.26% to 22.27%; compactness falls; two urban areas converge	Jatayu et al. (2023)
Central Java metropolitan corridor	2010-2020	Primary city stagnant; secondary cities develop more intensively	Indrayati et al. (2024)
East Java metropolitan area	2016-2019	High internal inequality; one of seven jurisdictions underdeveloped	Duriyyah & Rahmawati (2022)

Source: compiled by the authors from the cited studies. The regions differ in method and period and the findings are not pooled.

The pattern has a specific implication for infrastructure. If growth is concentrated in peri-urban rings and secondary cities, then the jurisdictions experiencing the fastest demand growth are systematically those with the smallest revenue bases and the least technical capacity, while the core city, which has both, faces slower growth. Infrastructure need and infrastructure capability are moving in opposite directions across the same functional region.

What fragmentation costs

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Ahrend et al. (2017) establish that cities with fragmented governance are less productive, that the presence of a metropolitan governance body mitigates the effect, and that the governance penalty is at least as important as the agglomeration benefit associated with city size. Quantified magnitudes for that penalty circulate in the authors' non-peer-reviewed summaries and are not reproduced here, because they could not be verified within the article itself; the direction and the authors' own comparison to the size effect are what this study relies on.

Goodman's (2019) distinction clarifies what would have to change. Horizontal fragmentation among many municipalities in one metropolitan region is one problem; vertical fragmentation across overlapping tiers and special-purpose bodies is another, and a metropolitan authority added to an already vertically fragmented system may increase the second while addressing the first. Kübler and Rochat (2019) show that the fiscal remedy is partial: intergovernmental grants reduce the mismatch between needs and resources significantly but to a limited degree, and the size of the contribution depends on higher tiers' redistributive effort rather than on the cooperation arrangement itself.

Delegation, not cooperation

The most operationally useful finding in the reviewed literature is Bel and Sebő's (2021). Their meta-regression across the contradictory cooperation literature finds that population size and governance form explain the divergence in results, with small populations and delegation to a higher tier of government producing the cost advantages, while transaction costs do not clearly account for the differences between studies.

This reframes the standard policy prescription. Exhortations to cooperate treat cooperation as a continuous variable to be increased. The evidence indicates it is a categorical one: what produces savings is not more consultation among equals but the transfer of a function to a body operating at a larger scale. Tavares and Feiock's (2018) typology names the alternatives precisely — imposed authority, delegated authority, contracts, and social embeddedness — and the evidence favours the second over the third and fourth for infrastructure services with scale economies.

Table 3. Assigning metropolitan infrastructure functions by their governing geography

Function	Geography that governs it	Fragmentation exposure	Indicated arrangement
Bulk water supply and wastewater treatment	Catchment and network	High	Delegated authority at basin or metro scale

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Solid waste disposal and treatment	Haulage economics and site availability	High	Delegated authority; scale economies documented
Trunk transport network	Commuting field	High	Delegated authority with metropolitan planning mandate
Local distribution and collection	Neighbourhood	Low	Retained by municipality
Land use designation	Contiguous built-up area	High but politically retained	Binding metropolitan spatial framework
Capital financing for shared assets	Beneficiary population	High	Cost sharing on measured benefit; higher-tier grant

Source: authors' derivation from the reviewed evidence. The indicated arrangements follow the finding that delegation to a higher tier, rather than cooperation as such, is associated with cost advantage.

Two rows carry qualifications. Land use designation is the function where the functional case for metropolitan authority is strongest and the political feasibility weakest, since it is the power local governments most closely guard; Moore-Cherry et al. (2022) find broad agreement that the metropolitan scale is right for land management and none on the mechanism, which is a description of exactly this impasse. And capital financing is the row with the thinnest verified evidence: no study located within the review window treats cross-boundary infrastructure financing as its subject, so the arrangement indicated is inferred from Kübler and Rochat's (2019) grant findings rather than established.

Implications and limitations

Three implications follow for practice. Infrastructure demand projection should be conducted at functional urban area rather than jurisdictional boundaries, which the global delineation now makes technically possible without commuting surveys. Function assignment should be decided by the geography that governs each service, as in Table 3, rather than uniformly by administrative tier. And where national statistical classification designates functionally urban settlements as rural — which Dijkstra et al. (2021) show is common in Asia — the resulting infrastructure standards understate what is required, so classification review is an infrastructure question and not only a statistical one.

Four limitations qualify these findings. First, the cost and productivity evidence derives from Swiss, United States and European settings, and no verified equivalent for Southeast Asia was located, so its application to Indonesian metropolitan regions is indicative rather than established. Second, quantified estimates of the fragmentation productivity penalty were omitted because they could not be verified in the peer-reviewed source, which weakens the

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magnitude claim while leaving the direction intact. Third, no verified study addresses cross-boundary infrastructure financing directly, so that row of Table 3 rests on inference. Fourth, the Indonesian studies differ in method, period and region and are reported separately rather than pooled, so the spatial pattern they describe is a convergence of independent findings rather than a single measured result.

5. CONCLUSION

The city that infrastructure serves and the city that plans infrastructure have come apart, and the gap is now measurable. A global delineation identifies 8,790 functional urban areas holding roughly 3.9 billion people, some 53 per cent of the world population, with commuting zones growing faster than cores; across 363 large cities, urban land expanded at 1.08 per cent annually between 1970 and 2014, with the influence of income growth on expansion strengthening markedly after 2000. National statistical classifications understate urban population in Asia, which means functionally urban settlements receive rural infrastructure standards.

Indonesian evidence describes where the growth has gone. Urban land in one Jakarta-Bandung corridor rose from 10.26 to 22.27 per cent of area between 2000 and 2020 while compactness fell and two urban areas merged; peri-urban change in Greater Jakarta was massive between 2011 and 2019 while the centre expanded at low intensity; highway access drove sprawl 40 to 50 kilometres out; and in a Central Java corridor the primary city was stagnant while secondary cities developed. The jurisdictions absorbing the fastest demand growth are therefore those with the weakest revenue bases and technical capacity, while the core city holds both and grows more slowly.

Fragmentation is not free. Cities with fragmented governance are less productive, an effect mitigated where a metropolitan body exists and which its authors judge at least as important as the benefit of city size, while fiscal transfers reduce the needs-resources mismatch significantly but only in part. The operative conclusion, however, concerns the form of the remedy rather than its necessity. The best available synthesis of the cooperation literature finds that cost advantages arise where a function is delegated to a higher tier, not where jurisdictions simply cooperate more. The design question is therefore which functions to delegate and to what scale — bulk water and wastewater to the catchment, waste treatment to the haulage economy, trunk transport to the commuting field, distribution and

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collection retained locally — and the answer for each is given by the geography that governs the service rather than by the boundary that happens to enclose it.

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DECLARATIONS

Author contributions (CRediT)

Crismon Alfajri Agus Pratama: conceptualisation; methodology; formal analysis; writing - original draft; writing - review and editing.

Conflict of interest

The authors declare that they have no competing interests.

Data availability

All data supporting the findings of this study are available within the article and from the publicly accessible sources cited therein.

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Declaration on the use of artificial intelligence

Claude (Anthropic) was used for language editing and for translation of the manuscript into English. The authors reviewed and verified all content, and take full responsibility for the final text. No generative tool was used for data analysis, for the interpretation of results, or for the generation of scholarly content. AI is not listed as an author.

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