

# Supplementary Materials: A Global Inventory of Urban Corridors Based on Perceptions and Night-Time Light Imagery

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## Examples from literature

### 1. Europe

A number of corridors are identified in Europe. Since many of them focus on the infrastructure development in between cities but not on the built environment itself, intrinsically they are defined rather by the space of flows than by the space of place [59]. This includes the seven hypothetical transnational *megacorridors* of the EU-funded CORRIDESIGN project (2000–2002) with axes such as Randstad–RhineRuhr or Randstad–Flemish Diamond [39,60,61] and the *Eurocorridors* which represent the backbones of the “Trans-European Networks” in transport (TEN-T) program, started in 1992 [62–64].

The largest European corridor in our literature review is the “Blue Banana” [65,66], a highly urbanized and densely populated area that reaches right across Western Europe from Birmingham to Milan, covering well over 1500 km in length. The region constitutes a largely homogeneous economic zone with large concentrations of industry, infrastructure (physical and telecommunications), cultural and educational centers [65]. Per capita income and employment rates are above the EU average [67]. The shape of the banana follows old trade routes which date back to Medieval and even Roman times (e.g., from the Alps along the Rhine river) and which gained renewed significance during the Industrial Revolution [65]. With the Alps and the North Sea as major barriers, there are large areas of discontinuous settlement. Thus, from a traffic infrastructure point of view, these areas are less connected which is also visible in the physical layout.

Part of the *Blue Banana* but separate corridor areas in their own right are, among others, the *RhineRuhr*, *Randstad* and *Flemish Diamond* areas which are alternately termed corridors [39,62], networks/nodes of corridors [68], network cities [42,73], metropolitan regions [69], polycentric urban regions (PURs) [70–73], or functional urban regions [69].

The *RhineRuhr* (or *Rhein-Ruhr*) area in Germany connects the Dortmund–Essen–Duisburg agglomeration with Cologne/Bonn. In the 19th century, the region started to thrive on coal and steel industries, boosted by the expansion of the railway system. Nowadays, a grid of motorways and express highways connects the main centers [68], following the historic routes and allowing for a large share of daily commutes to work and the emergence of something like a “common market” [69]. Campbell & Meades and Perkins & Robbins [70,71] describe the area as polycentric with several centers of similar size (although Cologne’s population is largest) and no primate city (i.e., dominant city in terms of size and significance). There is no clear definition of the RhineRuhr area: depending on the perception, it covers between 6000 km<sup>2</sup> with 9.5 million people (“morphological agglomeration”) and, if the total “functional urban region” is considered, 11,500 km<sup>2</sup> with 11.7 million people [69,70]. The main axes run along the area’s largest rivers, Rhine and Ruhr. Similarly, the *Randstad* in the Netherlands—with Amsterdam, The Hague, Rotterdam, Utrecht and smaller centers such as Delft or Haarlem—also has no primate city [71] and is dubbed “(mature) network city” [42] or corridor [39,62]. Each of the cities has its own economic basis: financial sector, tourism and an international airport in Amsterdam, government in The Hague, port industry in Rotterdam, service sector in Utrecht, and in between farmland and water [72]. The *Flemish Diamond*’s main cities—Brussels, Antwerp, Ghent and Leuven in Belgium—also have different functions: Brussels, for example, is seat of national and European governments, while Antwerp is an industrial centre with one of Europe’s main port [73]. Taubenböck & Wiesner [17] show the increasing settlement contiguity of these three networks of cities and classify their combined area as megaregion when comparing the settlement characteristics to other megaregions across the globe.

Figure 4 shows further areas which illustrate the variety of forms and extents in which corridors are perceived throughout Europe, for example the thinly populated Stockholm–Gothenburg corridor [74] versus the high-tech cluster along the M4 motorway from London to Bristol [75] or London–Cambridge with their complementary functions [76,77]. Several corridors start/end in Germany and transgress international boundaries (Karlsruhe–Vienna, Frankfurt–Prague, Dresden–Prague) [78,79]. Others run along rivers (Ebro, Rhône) [79,80] or coastal areas (Dublin–Belfast, Athens–Patras, Athens–Thessaloniki) [78,79].

Recent developments such as transport infrastructure or demographic changes may lead to the development of new urban corridors. Examples are the Thames Gateway east of London [81] through the completion of the high-speed rail link to the Channel tunnel in 2007 and Portugal's Algarve coast through a projected population growth [78,82].

Further areas in Europe make up economic zones but have not been classified as urban corridors yet. These have been identified as European growth poles which complement or extend the *Blue Banana* [65]. Among them are:

- *Golden Banana* (also referred to as *Mediterranean Banana* or *Sunbelt*) from Milan to Valencia/Alicante via Nice, Marseille and Barcelona [65,80].
- *Yellow Banana* from Paris to Warsaw via Cologne and Berlin (and further extending towards Rostock and Riga) [65].
- *European pentagon* with London, Paris, Hamburg, Munich and Milan, a concept coined by the European Spatial Development Perspective (ESDP) with 20% of the EU15's territory, 50% of its GDP and 40% of its population [72].

## 2. North America

While European corridors are shaped by their long history, the massive corridors in North America or Asia are a much more recent phenomenon and also grow at a considerably faster pace.

Without doubt, the most prominent urban corridor worldwide is the area along the US Northeast coast, roughly between Boston and Washington. The area is generally named Boswash (or Bos-Wash) but is also known as Megalopolis, East Coast Metroplex, I-95 Corridor, or BostWash [83]. Gottmann [84,85] was the first to describe and define the region in detail. It has since served as a model area for the delineation of other urban corridors. According to Gottmann [84,86], a megalopolis is a polynuclear urban system in which the individual metropolitan areas are coalescent while separated from other urban systems by less urbanized spaces. Using census data from 1950, Gottmann [84] estimates that about 30 million people live within an area which stretches almost 1000 km. [87] assumes that 18% of the US population live in the area, producing 20% of the Gross Domestic Product while covering only about 2% of the land area. Although the degree of interconnectedness is high (for example a high share of daily commutes to work), each metropolitan area is prominent in a certain area (e.g., New York: finance, commerce, media; Washington: government, administration; Philadelphia/Baltimore: culture, commerce, academia) [87]. Champion [88] sees this *Megalopolis* as precursor for the possible future development of RhineRuhr, Randstad and Flemish Diamond in Europe into a big polynucleated urban region (as also predicted by [71]).

For a long time, no other region in the US could match the status of the Boswash area. Over the last decade however, several reports [1,89,90] have identified other regions with characteristics of a megaregion. Most of these show typical criteria for an urban corridor system because of a strong focus on traffic infrastructure (interstate highways and high-speed rail covering about 150 to 1000 km) and an elongated shape. Examples are the *Gulf Coast*—which intersects with the Texas Triangle [91] and the *I-35 Corridor* [1]—or *Arizona Sun Corridor* [1,92,93]. Others, such as the Great Lakes megaregion [92,94], are omitted from this summary because of their galactic rather than linear shape, i.e., they resemble “a galaxy of stars and planets, held together by mutual gravitational attraction, but with large empty spaces between clusters” [95].

Somewhere in between a linear and galactic shape is the *Northern California* megaregion. The San Francisco Bay Area is home to over 7 million people, with the Silicon Valley being a model for

other technological hubs (such as the UK's M4 or the Malaysia Multimedia Supercorridor) [76]. *Florida* and the *Texas Triangle* also fit into this in-between category.

*Cascadia* too has a strong economy (high-tech and creative clusters) and stretches 700 km from Vancouver to Eugene (via Seattle and Portland), connecting around 8 million people in Canada and the USA [96]. The *Piedmont Atlantic* megaregion [1,89] reaches 900 km. A further potential megapolitan area [1] is the *Colorado Front Range* spanning from Fort Collins to Colorado Springs via Denver and (according to [89]) extending to Albuquerque (800 km).

Whebell [37] developed his original urban corridor theory (described above) using *Southern Ontario* as model region. This corridor can be expanded to include Québec, over 1100 km from Windsor. Yeates [97] describes urbanization processes along this extended axis. Of smaller dimension is the *Calgary–Edmonton corridor*: this 350 km stretch of land is held together by the two end nodes which are economically connected [98]. Urbanization along the linking highway is relatively sparse.

### 3. Central and South America

*Rio de Janeiro and São Paulo*, the two leading cities in the Paraíba River Valley, have grown increasingly connected, both physically and functionally. Consequently, UN-Habitat and Tolosa [2,99] identify this stretch—the “busiest traffic corridor in the country” [99]—as urban corridor. In another report however, UN-Habitat [45] classify the area, which has a population of 43 million, as mega-region. Other regions characterized as urban corridors by UN-Habitat [2] are the *Venezuela coastal corridor* (Maracaibo, Barquisimeto, Valencia, Caracas, Puerto La Cruz and Cumaná) and along the lower Paraná–Rio de la Plata river basin (*Montevideo–Buenos Aires–Rosario*), a corridor also identified by [100] who suggest that this axis can be extended across five countries to Santiago de Chile (Chile) as well as Belo Horizonte (Brazil) (marked with dotted lines in Figure 4 but not taken into account in our analysis).

Although Central and South America are highly urbanized, the number of large urban agglomerations—which experience a development towards polycentric patterns and urban corridors—is relatively small [45]. Therefore, the number of areas identified as urban corridors is limited in this region.

### 4. Asia

Judging from the number of areas (see Figure 4) and papers—over a third of the papers analyzed for this section—the urban corridor concept seems to be a largely Asian phenomenon. As noted above, many of them transgress international—and therefore also political and economic—boundaries. Economic zones—Pan-Japan Sea Zone, Pan-Bohai Zone, South China Zone, Indo-China Peninsula Zone, Singapore Growth Triangle, and Jabotabek (metropolitan region Jakarta)—might even merge into a continuous urban corridor from Japan via Korea along the Chinese coast and further to West Java (Figure 4) [53] with strong links to Sydney and Vancouver [52].

Because of its massive dimension, Asia's BESETO corridor (Figure 4), which was first identified by Choe [101], deserves special attention. This “mature transnational subregional urban corridor” [52] stretches in an inverted S-shape from Beijing to Tokyo via Pyongyang and Seoul, a densely populated region. It includes over 100 cities with over 200,000 people each [50,101–103]. According to [101], the corridor is 1500 km long (less than our method shows; see Table 2). Already in 1998, the total population within the corridor was close to 100 million [50]. BESETO not only transgresses several international (and economical) boundaries (China, North and South Korea, Japan) but also a 200 km wide water body. Flight times between Beijing and Tokyo are just above three hours and high-speed traffic links (e.g., Japan's high-speed Shinkansen bullet train) make it possible to traverse sections quickly. It can be subdivided into four smaller regions: Bohai Rim corridor, Shinuiju–Kaesong corridor, Seoul–Busan, and Fukuoka–Tokyo. Differences between these pose a challenge to economic integration, which [101] sees as unlikely to happen any time soon. The Bohai Rim corridor exceeds Choe's own delineation of the BESETO corridor, which omits some large cities such as Qingdao or Zhangjiakou. The Japanese subsection of BESETO has an unclear extent: some authors—like [101]—include the western part of Honshu, while for others it only stretches from

Tokyo to Kobe (including Yokohama, Nagoya, Kyoto and Osaka). This region can be traversed in just 2.5 h with the Shinkansen train and is home to over 60 million people in the megacities along the track plus another 10 million if the surrounding urban districts are included [23]. The area, classified as mega-region (not corridor) by UN-Habitat [24], roughly encompasses the Tōkaidō and Kansai regions; some authors also include the section from Osaka to Kitakyushu or Fukuoka (e.g., [101]).

A prominent large urban area in south China is Guangzhou—Hong Kong with the *Pearl River Delta* [20,50,104,105]. Over the last 30 years, the region experienced massive infrastructure construction, an increase in land use intensity and population density and shows characteristics of a megalopolis [106], mega-region [24,107], or functionally interrelated metropolitan region [108] but still with a large share of rural/agricultural population [109]. Spatially, the area has a galactic shape but the river delta restricts fast surface connections between Hong Kong/Shenzhen and Macau/Zhuhai. Thus, from a surface infrastructure point of view, the mega-region shows corridor-like connections, running from Hong Kong via Guangzhou to Macau in an inverted U-shape.

Figure 4 shows further urban corridors in China and Taiwan such as Beijing–Qinhuangdao [23], Shanghai–Nanjing and Shanghai–Hangzhou [110], the Hangzhou–Ningbo “periurbanization corridor” [111], Xining–Lanzhou–Yinchuan [112], the He-Xi Corridor from Lanzhou to Yumenguan [45,113], or Taiwan–Fujian (with varying extents) [50,53,105].

In India, development of urban corridors is often associated with planned growth along industrial or infrastructure corridors [23,114–117], most of which are still under construction, such as the Delhi–Mumbai Industrial Corridor, DMIC, which is planned to be 1500 km long and over 300 km wide with a modern multi-modal traffic infrastructure, industrial and investment clusters and “Smart Eco Cities” [118–120].

Malaysian urban development is often unplanned and along major roads, conversion of former rubber and oil palm plantations, or integration of existing towns into larger urban regions (e.g., Kuala Lumpur to Port Klang) [121]. Kuala Lumpur also has a special type of corridor: the Multimedia Super Corridor (MSC Malaysia), launched in 1996 and scheduled for completion by 2020 [105,121], with its own capital, Putrajaya [122]. Already, an extension of the corridor into neighboring districts (e.g., Johor Bahru, Nusajaya) has been observed [123]. Neither of the Malaysian corridors, however, go beyond an intra-urban dimension yet and are excluded from our analysis.

Smaller urban corridor regions have developed in Indonesia (Jakarta–Bandung) [48,76,124,125] and Vietnam [104].

The transborder region between Singapore, Malaysia and Indonesia is an economic growth centre known as SIJORI [123]. Campbell & Meades [126] argue that, unlike in many other parts of the world, the international borders ensure the economic performance of the region: Singapore provides better jobs, while Malaysia and Indonesia attract with cheaper goods and labor (see also [123]): labor-intensive and polluting industries are therefore hardly found in Singapore [126]. The three individual nations thus form two pairs of relations anchored in Singapore [53].

The large number of urban corridors in Asia reflects the high population growth, which is mainly absorbed by (mega-)cities [15]. Some of the world’s fastest-growing megacities include Delhi [119], Shanghai [23] or Dhaka [127], the latter of which not having been characterized as urban corridor yet but rather as mega-city dominated city-region [23].

## 5. Africa

The number of large cities in Africa is relatively small: [46] report 49 cities with over one million inhabitants in 2008 and only two—Cairo and Lagos—above 10 million (with Kinshasa expected to follow soon). Thus, corridor development is an emerging phenomenon in Africa, but most nations now see the potentials of such corridors and are starting to actively encourage an increased intra- and inter-regional cooperation in the form of development corridors [46,47], shown in Figure 4. A number of these run along centuries-old, pre-colonial trade routes [47]. These include the Maputo, Nacala, or Central development corridors [2,47,128,129] in the South-East and the Southern Mediterranean Coastal Region and Kenitra–El Jadida in the North [46,47]. Another corridor is emerging between Luanda (Angola) and N’Djamena (Chad), traversing several countries (Congo,

Gabon, Equatorial Guinea, Cameroon, Central African Republic) and incorporating a number of cities with over one million people (Kinshasa, Brazzaville, Douala, Yaoundé, Bangui) [47]. These corridors, however, are still in an early development stage and not further analyzed in this study.

Three African corridors deserve special attention: Nile Valley, GILA and Dakar–Touba (see Figure 4). The Nile Valley corridor stretches along a narrow strip from the Aswan dam to the Nile delta, well over 1000 km. The northern part of this corridor—the Greater Cairo and North Delta Region—is termed a corridor itself, consisting of the three smaller tangents Cairo–Suez (150 km), Cairo–Alexandria (225 km) and Cairo–Ismailia–Port Said (200 km). With a population of over 55 million, it is home to three quarters of the nation’s total [46].

A number of reports identify the *West African coast*—Ibadan and Lagos (Nigeria), Cotonou/Porto Novo (Benin), Lomé (Togo), Accra (Ghana)—as an urban corridor [46,87,103], covering about 600 km and housing 25 million people. Some interpretations of this corridor [2] include the stretch from Accra to Abidjan (Côte d’Ivoire), adding another 500 km to the region and putting the total population to 70 million, while others only delineate separate sections such as Accra–Tema [115] or Lagos–Ibadan [46]. The region is the driving force of the West African regional economy [104], but with a clustered settlement system, is not a cohesive mega-region yet [46]. Because of its development potential in spite of several international boundaries, the region has been given its own acronym, GILA (Greater Ibadan–Lagos–Accra).

On a smaller scale, the 200 km stretch from Dakar to Touba in Senegal is connected by a string of smaller, dynamic towns and cities along the connecting highway and train line [47].

## 6. Australasia

Due to the low population density, there are not many areas in Australasia or New Zealand that can be characterized as urban corridors, although sprawl (Melbourne, Sydney, Brisbane) and ribbon development (e.g., Cairns–Edmonton–Gordonvale) [130] can be observed. A large corridor along the east coast—from Cairns to Adelaide—has been termed an “emerging” corridor (Rimmer, 1990, in [50]), and smaller sections of it, for example the densely populated section between Gold Coast and Sunshine Coast (around Brisbane) or Sydney–Newcastle already form fully developed sub-sections which, with a length of under 200 km, are not included in our inventory.

### 6.1. Perceptions of Urban Corridors

Our questionnaire aimed at finding out the perception of urban corridors in the wider geo-scientific community. Although our sample size was quite small (40), some of the results described below show some strong trends.

The most common defining features of an urban corridor are:

- A spatial and/or functional “connectedness” between cities.
- A linear pattern in the form of a settlement or development axis along main traffic routes.

To be part of an urban corridor, about half of the participants thought that a city has to have a minimum population of 100,000 to 500,000. Over three quarters thought that an Urban Corridor could consist of a number of smaller cities that are located in close proximity of each other; no major city (like a world or global city) has to be part of it.

The maximum distance between two neighboring cities of a global Urban Corridor was thought to be between 50 and 200 km for almost half the participants.

As to the physical form of an Urban Corridor, a “linear shape with smaller branches” was selected by almost 90% of the participants. A “finger-shaped” form or a “linear form without branches” were each accepted by about 25%.

Three quarters of the participants believe that there should be a city (of an unspecified size) at each end of a corridor—as opposed to a city on just one end or somewhere in the middle, away from the ends.

Regarding the settlement density along the corridors, the participants agreed that there should not be many major gaps between the settlements—almost 75% thought that at least half the distance

between cities along a corridor should be built-up, and if physical features allow, settlement should be more or less continuous. About 25% accepted larger gaps (of more than half the distance) between the settlements.

The question whether an urban corridor can reach across a big water body such as a lake or sea turned out to be most ambiguous. A slight majority of the participants did not accept a big water body but almost as many did.

A number of alternative concepts were suggested. From these, the following were regarded as most similar to the term Urban Corridor:

- polycentric urban region.
- grid of cities.
- linear city.
- beads on a string.
- ribbon development.
- megacorridor.

The participants were then asked which Urban Corridors they knew. Answers here included:

- the Northeast of the US (“North East of US”, “US East Coast”, “Boswash”, “New York & Co.”).
- California (with San Francisco–San Jose–Silicon Valley).
- Nile delta.
- Germany’s Ruhr area.
- Hong Kong–Shenzhen–Guangzhou.

The questionnaire results confirm a number of aspects on which there seems to be a common agreement, while others—such as the question of whether an urban corridor can cross a big water body—show a strong discrepancy. Properties such as “linearity (with smaller branches)”, “connectedness”, “continuous settlement” and “a number of cities” show the largest degree of acceptance. Open questions (as regarding the minimum size of a city and the maximum distance of two cities within an urban corridor) obviously show a great range within the answers. The size of cities, thus, varies too much to assume a tendency, possibly because the global dimension of the question was not emphasized enough. A large extent due to the distance of 100 km and more between cities can be implied but not further defined.

### Questionnaire: Urban Corridors

This questionnaire aims at finding out the perception of “urban corridors” on a **global scale**. No background in urban geography is required. Please note that there are no “right” or “wrong” answers since everyone will have a different view of “urban corridors”.

#### Question 1

Are you familiar with the term “urban corridor”?

- ☐ yes
- ☐ no

#### Question 2

If yes: Please describe what, in your understanding, defines an “urban corridor”.

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#### Question 3

In your opinion, cities that are part of an “urban corridor” need to have a minimum population of \_\_\_\_\_ inhabitants.

## Question 4

Can an “urban corridor” consist of a number of smaller cities that are located in close proximity of each other or does at least one major city (like a world or global city) have to be part of it?

- ☐ a number of smaller cities
- ☐ at least one major city

## Question 5

To be part of a global “urban corridor”, the maximum distance between two neighbouring cities must not exceed (in your opinion) \_\_\_\_\_ km.

## Question 6

Tick all that apply: The shape of an “urban corridor” is...

- ☐ linear
- ☐ linear with smaller branches
- ☐ a number of branches radiating from a centre (finger-shaped)

## Question 7

A city is located

- ☐ at each end of a corridor
- ☐ at one end of a corridor
- ☐ away from the ends of a corridor (i.e., somewhere in the middle)

## Question 8

For you, gaps between settlements along the corridor can exist...

- ☐ only if an area is unsuitable for settlements (i.e., settlement more or less continuous)
- ☐ for up to half the distance between the cities
- ☐ for more than half the distance between the cities
- ☐ for more or less all the way between the cities (i.e., no settlements between the cities)

## Question 9

Can an “urban corridor” reach across a big water body (lake, sea)?

- ☐ yes
- ☐ no

## Question 10

Which alternative terms describe the concept of “urban corridors”? (Tick all that apply)

- ☐ ribbon development
- ☐ megacorridor
- ☐ strategic corridor
- ☐ beads on a string
- ☐ linear city
- ☐ polycentric urban region
- ☐ grid of cities
- ☐ other(s): \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

## Question 11

Which, if any, “urban corridors” do you know?

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\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Question 12

Please draw a polygon around the areas you regard as “urban corridor”.

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