Final Research Report

Measuring, monitoring and translating urban liveability in Bangkok:

An international case study with implications for Australian cities

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Executive Summary

The UN Sustainable Development Goals (SDGs) explicitly recognise cities as being at the forefront of efforts to tackle climate change and the rise of non-communicable disease. There is growing interest among decision-makers in developing metrics and tools that can be used to measure and monitor the liveability of our cities. However, measuring and mapping liveability across a city is an immense undertaking, and scholars have identified a need to build capacity and develop spatial data infrastructure in low-to-middle income countries, where urbanisation is occurring most rapidly.

This partnership project aimed to further refine knowledge of context-specific liveability in a rapidly urbanising low-to-middle income city context (Bangkok, Thailand), and generate indicators that can be applied to low-to-middle income cities and other contexts. Activities included developing a suite of 65 liveability indicators aligned to the SDGs, housed in a web-based portal, as well as creating and sharing capacity building resources and tools to support ongoing use of the indicators.

This project demonstrated proof-of-concept that open source data can be used to create liveability indicators for Bangkok when local spatial data are not available. Furthermore, indicators can be updated over time by the Bangkok Metropolitan Administration through the Spatial Urban Indicators Framework developed for this project. The indicators will be embedded into Phase 3 of Bangkok's 20-year Development Plan (2023-2027). Indicators and their methodology have also been applied to regional Victoria and a global indicators project.

Summary

Why measure and monitor liveability?

Cities have long been recognised as important settings for promoting health and wellbeing, and are receiving increasing attention in the 21st century. Indeed, the UN Sustainable Development Goals (SDGs) explicitly recognise cities as being at the forefront of efforts to tackle climate change and the rise of non-communicable disease. Meanwhile, the world is rapidly urbanising, especially in low-to-middle income countries in Asia and Africa: by 2050, cities in Asia and Africa will be home to three-quarters of the world's urbanised population.

Around the world, there is growing interest among decision-makers for developing metrics and tools to measure and monitor the liveability of our cities and the extent to which they promote health and wellbeing for all. However, measuring and mapping liveability across a city is an immense undertaking, and scholars have identified a need to build capacity and develop spatial data infrastructure, particularly for low-to-middle income countries, to achieve this goal.

What did we do?

This partnership project aimed to further refine knowledge of context-specific liveability in a rapidly urbanising low-to-middle income city context (Bangkok, Thailand), through a partnership between the Bangkok Metropolitan Administration, VicHealth, the Centre for Urban Research at RMIT University, the UN Global Compact – Cities Programme, and the Victorian Government Department of Health and Human Services. This included developing a suite of 65 spatial liveability indicators aligned to the SDGs, made available for policy and practice use through an online open-access portal. Indicators and their methodology have also been made available for use as part of regional Victoria liveability assessments and a global indicators project.

The project was implemented in four phases:

Phase 01

Refine Bangkok's liveability indicators framework, take an inventory of available spatial data, Bangkok Metropolitan Administration review of indicators and data

Phase 02

Calculate liveability indicators, integrate indicators into a web-based portal, map indicators to the SDGs, Bangkok Metropolitan Administration selects 'case study' geographic areas of interest for deeper interrogation

Phase 03

Build capacity through online training webinars and virtual meetings, digital tools and project documentation

Phase 04

Development of Bangkok Liveability Monitoring Framework, Bangkok Metropolitan Administration-led policy proposal

Summary

What are the recommendations for other cities?

- Open source (i.e., freely available) spatial data can be used to create liveability indicators for cities in low-to-middle income countries and other geographies when local spatial data are incomplete or not available
- These liveability indicators can be updated over time using the freely available Spatial Urban Indicators Framework developed as part of this project
- Future partnerships should prioritise local knowledge at each step; for example, local reviews of indicators, datasets, mapping, and priorities are critical to developing relevant indicators
- Liveability indicators should be aligned to the SDG targets and indicators
- Implementing a mix of face-to-face activities and online resources is important for establishing mutual trust and encouraging knowledge sharing, while accommodating changes in personnel and developing a resource library
- International capacity building efforts should include an extended handover period, a cross-cultural (and bilingual, if relevant) partner liaison, and locally designed project governance structures (e.g., local project Steering Committee and Working Groups)

Policy outcomes in Bangkok

A key policy outcome from this project was the Bangkok Metropolitan Administration's development of the Bangkok Liveability Monitoring Framework and in-principle commitments to incorporation of liveability indicators into Phase 3 (2023-2027) of Bangkok's 20-year Development Plan. This is expected to be completed in late 2021. The Bangkok Liveability Monitoring Framework has been drafted as a policy proposal by the Strategy and Evaluation Department and liveability indicators in the framework have been aligned to the 20-year Development Plan. The COVID-19 pandemic has necessitated the Bangkok Metropolitan Administration's immediate focus on coordinating the public health response. However, it is anticipated that the Bangkok Liveability Monitoring Framework and indicators developed through this project will continue to play a key role through ongoing monitoring of Bangkok's long-term recovery from the pandemic, achievement of the aims of the 20-year Development Plan, and progress towards the SDGs.

Relevance to Victoria and regional Australia

While the indicators here were developed for Bangkok, these methods and indicators have been adapted and applied to Australia. The SUI framework developed in this partnership project provided the methodological framework for automating the generation of indicators that are in use for the regional Victoria liveability program at the Centre for Urban Research (RMIT University). Shared knowledge contributed through this project and other innovative methodologies have also influenced methods used to develop regional liveability indicators in several regional towns across Victoria and Tasmania (Davern et al., 2018b, Davern et al., 2018c, Davern et al., 2018a, Davern et al., 2019a, Davern et al., 2019b). Regional Liveability Assessments conducted to date have drawn on shared methods, and the co-production of knowledge across projects involving a range of different policy stakeholders in specific local contexts. These methods and knowledge have also expanded understanding of liveability beyond urban-Australian-centric definitions. The liveability of neighbourhoods and suburbs across Victoria and Australia can also be assessed and understood when viewed with existing liveability indicators already available through the Australian Urban Observatory, where liveability is measured for the 21 largest cities of Australia, including Melbourne, Geelong, Ballarat, Bendigo and Wodonga in Victoria. This information is critical to understanding whether Victorian urban planning policies are being achieved, or where changes to the built environment should be prioritised to support better health and wellbeing outcomes and reduce inequities across Victoria.

Relevance to other cities globally

The SUI framework developed through this project uses free, open source software and data, and therefore can be used by other cities globally to measure and monitor liveability using a similar approach. Further, the SUI framework is of particular relevance to other cities in low-to-middle income countries, where local spatial data may not be available or nationally consistent. It marks a significant global contribution in tool provision to track progress towards the SDGs.

Indeed, data acquisition and indicator methods approaches developed through this partnership project are also being used in a Global Indicators Project, which encompasses 25 diverse cities across 19 countries and six regions. The 4-year project is being led by an international team of researchers and collaborators associated with the International Physical Activity and Environment Network (IPEN). Methods developed for pre-processing of open and custom data for built environment analysis in this present partnership project have been incorporated into the Global Indicators Project and are described elsewhere (Liu et al., 2021).

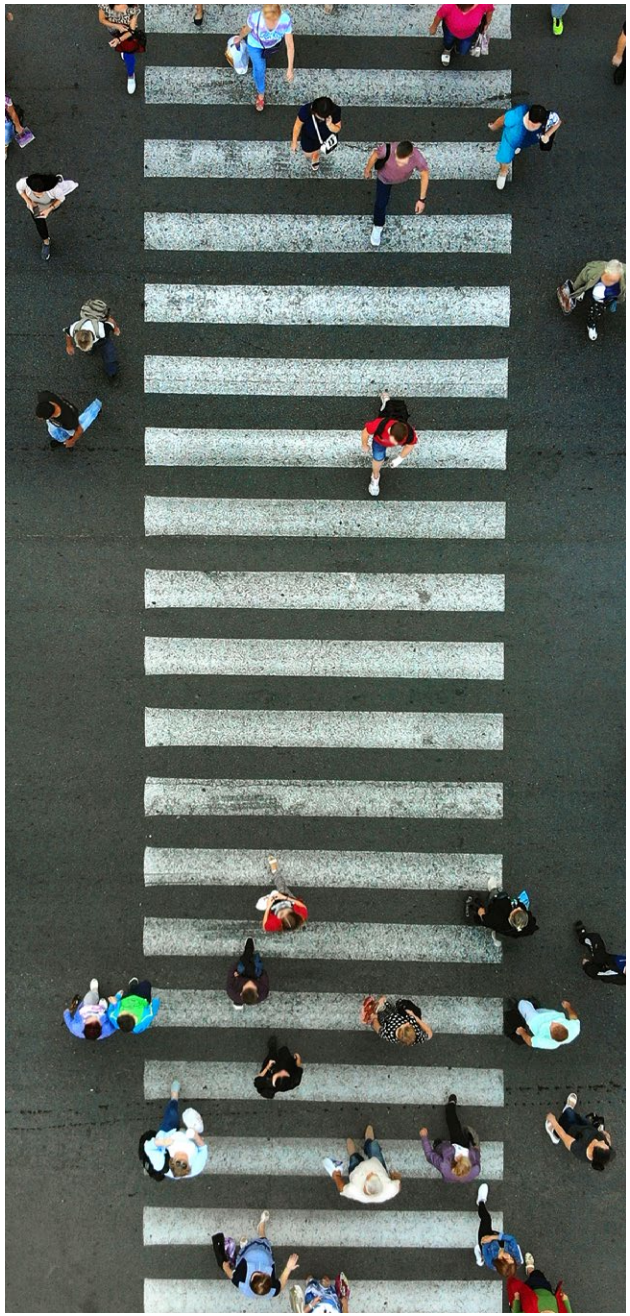
Research Context

Urban liveability, health and wellbeing in the context of the Sustainable Development Goals

Cities have long been recognised as being important settings for promoting health and wellbeing, and are receiving increasing attention in the 21st century due to a number of key challenges, including climate change, the rise of non-communicable disease, and rapid urbanisation (Giles-Corti et al., 2016). Critical urban infrastructure, such as access to sustainable forms of transport (public transport, walking and cycling infrastructure), decent and affordable housing, parks and recreational opportunities are linked to physical health as well as mental health and social connection (Badland et al., 2014). These resources and opportunities make up the liveability of our cities and create the daily living conditions that determine our health, otherwise known as the social determinants of health (Badland et al., 2014). A liveable city has been defined as a city that is:

> "safe, attractive, socially cohesive and inclusive, and environmentally sustainable; with affordable and diverse housing linked to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities; via convenient public transport, walking and cycling infrastructure" (Lowe et al., 2013).

There is now a substantial body of research showing the links between urban liveability, health and wellbeing, and major global bodies have taken note. In 2016, the World Health Organization's Shanghai Declaration recognised that cities would play a major role in reducing non-communicable disease and promoting good health across populations (World Health Organization, 2016). The 2030 Agenda for Sustainable Development, along with the New Urban Agenda and 17 Sustainable Development Goals (SDGs), recognise the importance of creating liveable cities to address the pressing global challenges of climate change, urbanisation, and rising non-communicable disease (United Nations, United Nations, n.d.). The 2030 Agenda, adopted by all UN member states, aligns strongly with the concept of liveability, as evident in SDG 11: Making cities inclusive, safe, resilient and sustainable, and its associated targets and indicators (United Nations Development Programme, 2015). It is clear that a focus on creating liveable cities will be a centrepiece of efforts to achieve the 2030 Agenda and the SDGs.



Liveability in diverse contexts

While liveability is increasingly included in global strategies and efforts to improve population health, the majority of evidence and liveability frameworks generated to-date have been produced from the perspective of cities in high-income countries and their cities. This is despite the fact that most of the future urban population growth is projected to occur in cities in low-to-middle income countries, especially in Asia and Africa. Indeed, by 2050, Asian and African cities will be home to three-quarters of the world's urbanised population (UN Department of Economic and Social Affairs - Population Division, 2018). These cities face a multifaceted set of additional challenges; for example, in addition to rapid population growth and urbanisation, already one in three people in urban Asia live in areas characterised by poor housing quality, overcrowding, lack of adequate sanitation infrastructure or clean drinking water, which are critical infrastructure for supporting and protecting health (WHO and UN HABITAT, 2016, UN Department of Economic and Social Affairs - Population Division, 2018). Decisions made about the layout and distribution of hard infrastructure in these cities will be critical to achieving the SDGs.

Building capacity in measuring and monitoring liveability

Globally, there is growing interest among decision-makers in developing metrics and tools that could be used to measure and monitor progress towards liveability and the SDGs over time (Pineo et al., 2018a, Pineo et al., 2018b). Such tools can help governments and stakeholders track progress towards key commitments, develop more targeted and place-based strategies and priorities, and understand how to better address inequities within a city.

However, measuring and mapping liveability across a city is a substantial undertaking, requiring expertise in sourcing and collecting spatial data, as well as technical skills involved in calculation and mapping using specialist software. Urban health scholars have identified a need to build capacity in these skills and develop spatial data infrastructure, particularly for low-to-middle income countries, possibly through open-source data (Prasad et al., 2016). Our pilot project identified capacity building in these areas as a key priority (Alderton et al., 2019). In addition, efforts to measure and map liveability across cities would benefit from tangible examples of: (1) how to build local capacity and expertise; (2) models of engagement; and (3) benefits of reciprocal knowledge sharing. Policy-relevant and readily useable tools and frameworks that can be applied to cities and different geographies (e.g. regional contexts) around the world are of great value in advancing global efforts towards the SDGs in cities.

Partnerships around the SDGs and liveability

The 2030 Agenda and SDGs framework stress the importance of partnerships across countries, sectors, and levels of government as crucial to achieving the goals (United Nations, n.d.). Indeed, partnerships are crucial to efforts to improve the liveability of cities, as liveability itself in shaped by decisions made by numerous sectors, such as transport, housing, education, health, arts and culture, among others. Hence, improving urban liveability requires engaging with a diverse range of actors beyond the health sector.

Partnerships around liveability need not be limited to local partnerships, and indeed much can be gained through international partnerships. Further, capacity building through North-South partnerships (i.e., between high- and low-to-middle income country contexts) is a key element of SDG 17: Revitalise the global partnership for sustainable development (United Nations, 2015). International partnerships can enable the sharing of experiences of similar challenges, knowledge about potential solutions, and expertise. Tangible examples of partnerships across diverse contexts are useful in guiding future projects aimed at advancing the 2030 Agenda.

Approach

Project aims

This partnership project aimed to further refine knowledge of context-specific liveability in a rapidly urbanising low-to-middle income city context (Bangkok, Thailand). This included developing a suite of online spatial liveability indicators aligned to the SDGs, with the aim of building long-term local capacity in monitoring liveability and progress towards the SDGs.

Specific project objectives included:

01

Identify and source open source liveability spatial data inputs and indicators aligned with the SDGs and suitable for use in the Bangkok context;

02

Apply and test conceptually relevant liveability indicators across Bangkok;

03

Develop the capacity of the Bangkok Metropolitan Administration for using liveability data in policy and planning; and

04

Generate tools and resources that maximise the useability and scalability of indicators for application for different cities and geographies.

Our approach was anchored in several principles. First, we started from the principle that local knowledge about Bangkok's context should be prioritised each step of the way. Second, we understood the process of knowledge sharing to be a reciprocal process – rather than one-way –occurring continuously across the project's lifespan. Third, we viewed capacity building as adult learning and sought to apply concepts from education pedagogy to these activities.

Partner engagement across Bangkok and Melbourne

The partnership underpinning this project was a key strength. Project partners included the Bangkok Metropolitan Administration, VicHealth, the Centre for Urban Research at RMIT University, the UN Global Compact – Cities Programme, and the Victorian Government Department of Health and Human Services.

The project governance structure in Bangkok was determined by the Bangkok Metropolitan Administration and included the establishment of a project Steering Committee, a Field Action Working Group, and a Strategic Action Working Group. A bilingual liaison within the Bangkok Metropolitan Administration facilitated communication between Bangkok- and Melbourne-based partners and coordinated project activities in Bangkok. The project was endorsed by the Governor of Bangkok and Bangkok Metropolitan Administration executive team.

Project activities involved a mix of virtual and face-to-face meetings between Bangkok and Melbourne-based partners. Face-to-face meetings were held in 2017, 2018 and 2019. Additional face-to-face meetings were scheduled for 2020, but had to be moved online because of COVID travel restrictions. Representatives from Melbourne-based partner organisations provided input into project activities at quarterly meetings.

Structure of this project

This project was structured into four phases, as illustrated in Figure 1, and further explained in the following sections. Importantly, although the phases appear linear, in practice these were overlapping and iterative. For example, the review of indicators and spatial datasets by the Bangkok Metropolitan Administration (Phase 1) and the calculation of indicators (Phase 2) were iterative processes. Calculated liveability indicators were reviewed by the Bangkok Metropolitan Administration, which prompted deeper discussion of the spatial datasets used. In some instances, this led to further refinement and re-calculation of indicators. These phases were purposefully iterative to maximise knowledge sharing between Bangkok- and Melbourne-based partners.

Figure 1. This project was structured into four phases, with the major objectives of each phase shown above. Although depicted as a linear process, it was an iterative in practice.

Phase 01

Source spatial data for measuring liveability

Starting from the Pilot Bangkok Liveability Framework developed under through our 2017 pilot project (Alderton et al., 2019, Alderton et al., 2018), Phase 1 involved taking an inventory of the spatial datasets available to measure liveability in Bangkok. This included identifying indicators for which local spatial data was readily available, as well as further investigation of indicators identified by the Bangkok Metropolitan Administration as being important to representing liveability in Bangkok, but for which high-quality local datasets had not been identified. To address these data gaps, a spatial analyst based at RMIT University identified appropriate open source (i.e. freely available online, such as satellite imagery) spatial datasets, which were then reviewed by the Bangkok Metropolitan Administration to determine their relevance for Bangkok's context.

Phase 02

Apply and test liveability indicators

Liveability indicators were calculated for districts, and where available, subdistricts, in Bangkok. These indicators were then integrated into the web-based liveability portal 'Healthy, Liveable Bangkok'. In this portal each indicator can be mapped across Bangkok.

The development of software for supporting indicator calculation, summary and output in a range of formats—the Spatial Urban Indicators (SUI) framework—was proposed as a solution for the Bangkok project. Rather than being a 'one-off' analysis, the SUI framework is a software workflow which could be used by the Bangkok Metropolitan Administration to update indicators over time as new data become available. Technical details of the SUI framework are presented in Appendix A. A list of spatial datasets used – both local and open source – is provided in Appendix B.

The Bangkok Liveability Monitoring Framework conceptualised the indicators as a series of 65 indicators covering 24 indicator domains. From the software workflow perspective, these indicators were considered in methodological terms as relating to small area (district and subdistrict) summaries derived through: 1) linkage with administrative data using district and/or subdistrict codes; 2) overlay with satellite imagery; and 3) pedestrian accessibility analyses for specific destination types using sample points as proxies for dwelling locations.

In tandem with the calculation and mapping of indicators, the Steering Committee in Bangkok used initial maps of indicators to identify precincts of interest for deeper exploration.

Phase 03

Capacity building

Capacity building activities included a range of face-to-face and virtual meetings and resources. For example, in 2019, a delegation of leaders from the Bangkok Metropolitan Administration, including the Governor of Bangkok, visited RMIT University in Melbourne to take part in roundtable discussions with Melbourne-based partners, reflect on shared challenges and potential solutions, review project progress, and establish capacity building priorities for the Bangkok Metropolitan Administration. In 2020, the COVID-19 pandemic resulted in face-to-face training (originally planned to take place in Bangkok) being converted into online activities, including virtual meetings, training videos and webinars, and digital training materials. The online format of these activities had the benefit of ensuring materials could be turned into a resource library and used by new staff. This became an important priority given the reassignment of staff and resources within Bangkok Metropolitan Administration in order respond to the pandemic.

Phase 04

Generate tools for knowledge translation

A senior director in the Bangkok Metropolitan Administration led the development of the Bangkok Liveability Monitoring Framework policy proposal and its alignment to Bangkok's existing 20-year Development Plan. This included identifying gaps in the 20-year Development Plan and developing a proposal to incorporate indicators from the Bangkok Liveability Monitoring Framework into the 20-year Development Plan Phase 3 (2023-2027) to address these gaps and monitor achievement of urban planning policies over time.

Results

Results

Spatial datasets and liveability indicators

A total of 65 liveability indicators were created and housed in a web-based liveability indicators portal, Healthy, Liveable Bangkok, with hosting by the International Institute of Sustainable Development's Tracking Progress portal.

Hosting fees through June 2023 were funded through this project to enable a longer transition period, which was viewed as critical to ongoing indicator use given that the Bangkok Metropolitan Administration is leading Bangkok's public health response to the COVID-19 pandemic.

Figure 2 shows the portal interface with an example of a liveability indicator, the annual mean Normalised Difference Vegetation Index (NDVI), mapped across Bangkok at the district scale.

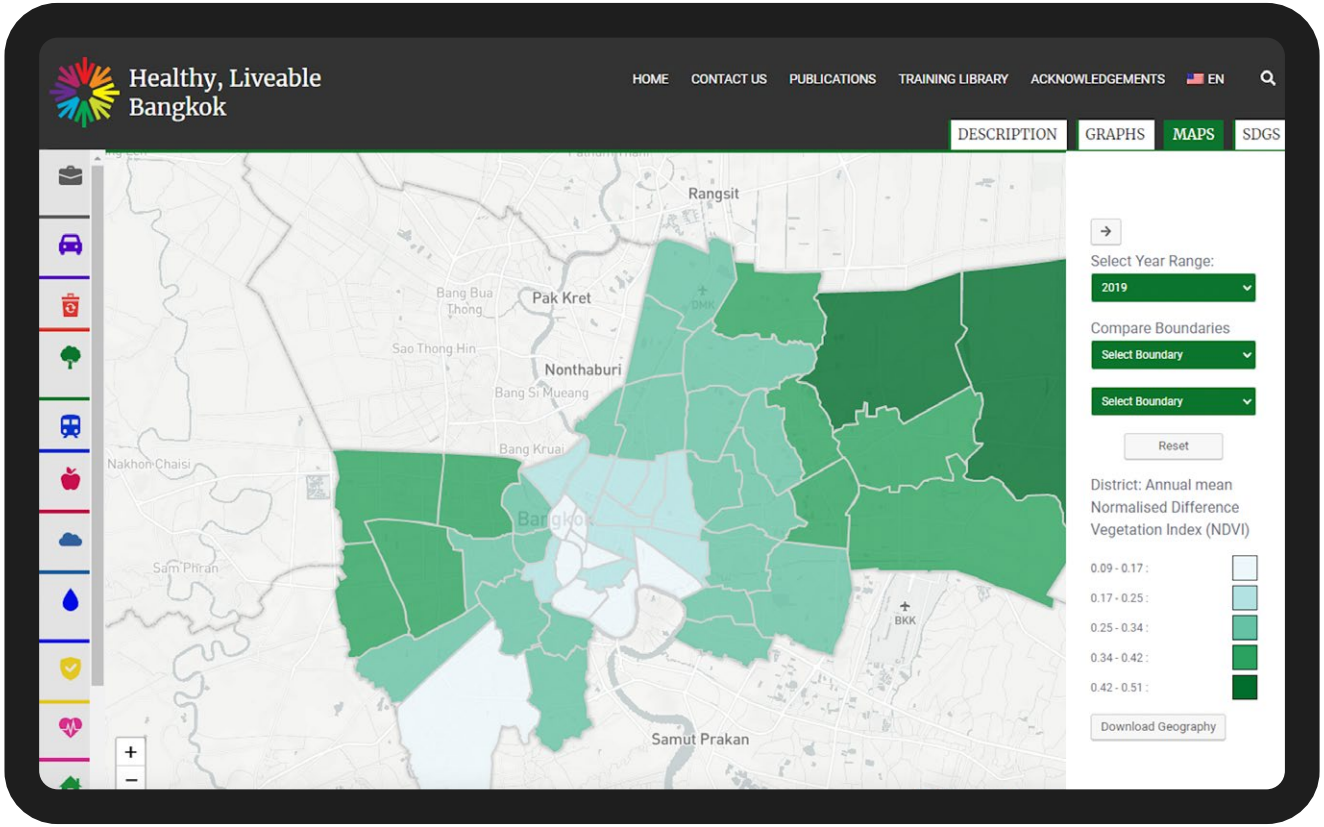


Figure 2. An example of a liveability indicator, mapped at the district scale across Bangkok, as displayed in the indicators portal. Acknowledgements: Indicators site: © RMIT University, 2021 (2021). | Indicator data: Annual mean Normalised Difference Vegetation Index: Landsat-8 data courtesy of the U.S. Geological Survey, processed using Google Earth Engine. | District boundary data: Bangkok Metropolitan Administration (BangkokGIS). Retrieved 25 July 2019. | Map data: © OpenStreetMap contributors (https://www.openstreetmap.org/), CC-BY-SA (https://creativecommons.org/licenses/by-sa/2.0/). | The Tracking Progress site uses Sparkjoy GeoC WordPress Theme version 1.9, © Sparkjoy Studios, 2018. | The indicators portal is housed by the International Institute of Sustainable Development's Tracking Progress platform (https://www.tracking-progress.org/) with site development provided by Sparkjoy Studios (https://sparkjoy.com/). | The map displayed in the image above was created using Leaflet (https://leafletjs.com/) and imagery by Mapbox (https://www.mapbox.com/).

Table 1. Liveability indicators and alignment with SDGs and targets

Table 1. Shows the liveability indicators created for Bangkok. Indicators were calculated at the smallest geographic scale available (e.g., subdistrict, district) to enable decision-makers to identify any inequities in infrastructure provision within the city of Bangkok. Each indicator was rated in various ways (e.g., per 10,000 population, per km2) to enable a nuanced understanding of infrastructure provision across Bangkok. Figures 3 and 4 show an example of an indicator rated in two ways: in relation to the geographic area of a district (per km2) and in relation to the population served (per 10,000 population).

				Rating(s)					
#	Liveability theme	Indicator	Scale(s) of aggregation	N/A	Count	Count per km²	Count per 1,000 population	Count per 10,000 population	SDGs (targets)
1	Water quality/ pollution	Canal water storage: average dissolved oxygen (mg/L)	District	●					6 (6.3), 12, 14
2	Water quality/ pollution	Canal water storage: average biochemical oxygen demand (mg/L)	District	●					6 (6.3), 12, 14
3	Water quality/ pollution	Canal water storage sample locations	District		●	●		●	6
4	Water quality/ pollution	Canal water storage biochemical oxygen demand < 6 mg/L	District	●					6 (6.3), 12, 14
5	Reduced/no car congestion	Number of main road traffic jams	District	●					11
6	Zero waste	Annual solid waste (tonnes)	District	●					12 (12.5)
7	Zero waste	Annual recyclable waste (tonnes)	District	●					1 2 (12.5)
8	Zero waste	Percentage recyclable waste (tonnes)	District	●					12 (12.5)
9	Zero waste	Annual hazardous waste (kg)	District	●					12
10	Zero waste	Percentage hazardous waste	District	●					12
11	No flooding	Main road flood area location count	Subdistrict, district		●	●		●	9, 13

Table 1. Liveability indicators and alignment with SDGs and targets

#	Liveability theme	Indicator	Scale(s) of aggregation	Rating(s)					SDGs (targets)
				N/A	Count	Count per km²	Count per 1,000 population	Count per 10,000 population	
12	No flooding	Average days of rain (main road flood areas)	Subdistrict, district	●					13
13	No flooding	Average maximum intensity (main road flood areas)	Subdistrict, district	●					9, 13
14	No flooding	Average days of flooding (main road flood areas)	Subdistrict, district	●					9, 13
15	No flooding	Vulnerable flood area count	Subdistrict, district		●	●		●	9, 13
16	High quality air	Air quality monitoring stations	District		●	●		●	3, 9 (9.1), 12
17	High quality air	Number of days PM 2.5 exceeds Thai standard (50 µg/m³)	District	●					3 (3.9), 12
18	High quality air	Number of days PM 2.5 exceeds WHO standard (25 µg/m³)	District	●					3 (3.9), 12
19	High quality air	Annual average nitrogen dioxide (1-e6 mmol/m²)	Subdistrict, district	●					3 (3.9), 12
20	A safe environment	Fire incidence (count)	District		●	●		●	3
21	A safe environment	Locations with reported crime (count)	District	●					3, 16
22	A safe environment	Locations with reported road accidents (count)	District	●					3 (3.6),
23	Green space, pocket parks	Total public green area percentage	District	●					11 (11.7), 3
24	Green space, pocket parks	Total public green area per capita (m²)	District	●					11 (11.7), 3
25	Green space, pocket parks	Green areas (count)	District	●					11 (11.7), 3
26	Greater tree coverage to provide shade	Annual mean Normalised Difference Vegetation Index	Subdistrict, district	●					11 (11.7), 15 (15.2), 3

Table 1. Liveability indicators and alignment with SDGs and targets

#	Liveability theme	Indicator	Scale(s) of aggregation	Rating(s)					SDGs (targets)
				N/A	Count	Count per km²	Count per 1,000 population	Count per 10,000 population	
27	Greater tree coverage to provide shade	Annual mean Enhanced Vegetation Index	Subdistrict, district	●					11 (11.7), 15 (15.2), 3
28	Greater tree coverage to provide shade	Vegetation Percent (mean)	Subdistrict, district	●					11 (11.7), 15 (15.2), 3
29	Greater tree coverage to provide shade	Vegetation Percent (standard deviation)	Subdistrict, district	●					11 (11.7), 15 (15.2), 3
30	Areas for passive recreation and physical activity	Percentage of residents living within 400 metres of public open space	Subdistrict, district	●					11 (11.7), 3
31	Areas for passive recreation and physical activity	Percentage of residents living within 400 metres of large (1.5 hectares or larger) public open space	Subdistrict, district	●					11 (11.7), 3
32	Mass transit availability; connected public transport networks; increased provision of transit-oriented developments	Percentage of residents living within 800 metres of a train station	Subdistrict, district	●					11 (11.2), 3, 9
33	Healthy population	Percentage of residents living within 800 metres of a ferry terminal or pier	Subdistrict, district	●					11 (11.2), 3, 9
34	Healthy population	Percentage of residents living 800 metres distance of any public transport	Subdistrict, district	●					11 (11.2), 3, 9
35	Job security	Holders of a state welfare card in Bangkok (count)	District	●					1 (1.2, 1.3)
36	Job security	Registered farmer households expected to be impacted by drought (count)	District	●					2 (2.4)
37	Healthy population	Average age (years)	Subdistrict, district	●					3
38	Healthy population	Health centres (count)	Subdistrict, district		●	●		●	3, 9, 11
39	Healthy population	Mental and behavioural disorder outpatients (count)*	Subdistrict, district		●	●		●	3 (3.4)

Table 1. Liveability indicators and alignment with SDGs and targets

#	Liveability theme	Indicator	Scale(s) of aggregation	Rating(s)					SDGs (targets)
				N/A	Count	Count per km²	Count per 1,000 population	Count per 10,000 population	
40	Healthy population	Hypertension outpatients (count)*	Subdistrict, district		●	●		●	3 (3.4)
41	Healthy population	Diabetes outpatients (count)*	Subdistrict, district		●	●		●	3 (3.4)
42	Healthy population	Combined vital diseases (mental and behavioural disorders, hypertension, diabetes outpatients) (count)*	Subdistrict, district		●	●		●	3 (3.4)
43	Quality food	Percentage of residents living 800 metres distance of a supermarket	Subdistrict, district	●					3, 11
44	Quality food	Restaurants (count)	District		●	●		●	11
45	Quality food	Supermarkets (count)	District		●	●		●	3, 11
46	Quality food	Minimarts (count)	District		●	●		●	3, 11
47	Quality food	Food stalls (count)	District		●	●		●	3, 11
48	Quality food	Markets (count)	District		●	●		●	3, 11
49	Quality food	Permitted sidewalk hawker/stall locations	District		●	●		●	3, 11
50	Quality food	Hawkers/stalls (count)	District		●	●		●	3, 11
51	Quality food	Food quality tests (count)	District		●	●		●	2 (2.1), 3, 11
52	Quality food	Percentage of food standards (of 9 in total) with 100% test pass rate	District	●					2 (2.1), 3, 11
53	High quality education and schools	Primary schools (count)	Subdistrict, district		●		●		4, 11

Table 1. Liveability indicators and alignment with SDGs and targets

#	Liveability theme	Indicator	Scale(s) of aggregation	Rating(s)					SDGs (targets)
				N/A	Count	Count per km²	Count per 1,000 population	Count per 10,000 population	
54	High quality education and schools	Average National General Education (Ordinary National Educational Test, O-NET) score for Bangkok Metropolitan Administration primary schools for each of four core subjects (Thai, mathematics, science and English)	District	●					4 (4.1)
55	Access to social infrastructure^	Temples (count)	District		●		●		3, 11
56	Access to social infrastructure^	Museums (count)	Subdistrict, district		●		●		3, 11
57	Access to social infrastructure^	Youth centres (count)	District		●		●		3, 11
58	Access to social infrastructure^	Visits to youth centres (count)	District		●		●		3, 11
59	Access to social infrastructure^	Sport centres (count)	District		●		●		3, 11
60	Access to social infrastructure^	Visits to sport centres (count)	District		●		●		3, 11
61	Access to social infrastructure^	Sport yards (count)	District		●		●		3, 11
62	Access to social infrastructure^	Visits to sport yards (count)	District		●		●		3, 11
63	Opportunity to earn a fair wage	Coefficient of inequality	Subdistrict, district	●					10
64	Opportunity to earn a fair wage	Average monthly cost of living per person (, baht)	Subdistrict, district	●					1, 10
65	Local employment opportunities	Percentage contribution of local taxes to overall Bangkok Metropolitan Administration tax revenue	District	●					8, 11

Notes: *Indicates liveability indicators for which calculation methods were developed, but due to issues in data quality, these indicators will be calculated by the Bangkok Metropolitan Administration and integrated into the portal pending the updating of local spatial datasets. ^Social infrastructure in the Bangkok context, as defined by Bangkok Metropolitan Administration leaders during the pilot project, refers to temples, museums, multi-purpose local community centres, music and other cultural events that provide opportunities for people to come together (Alderton et al., 2020).

Results

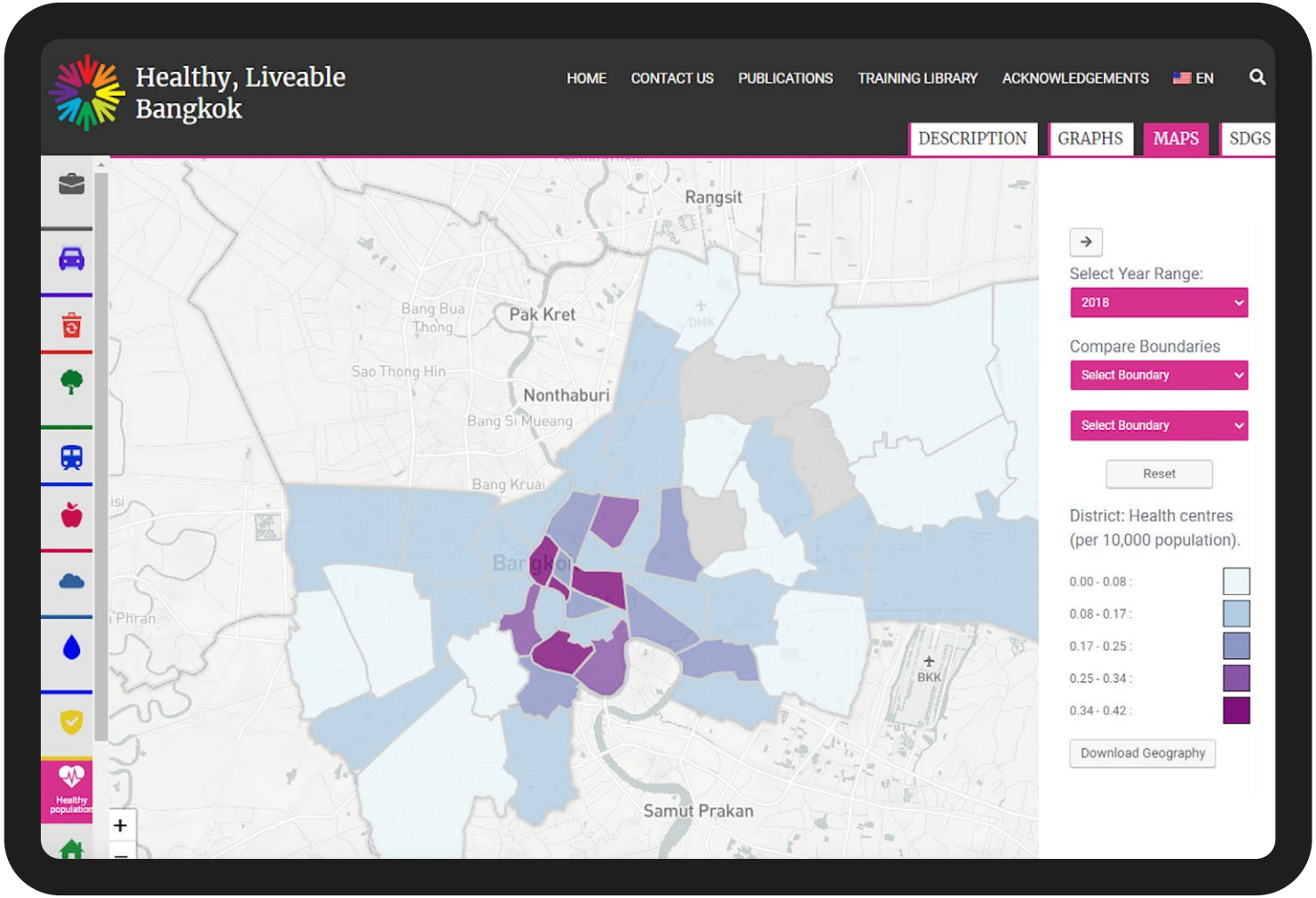


Figure 3. An example of a liveability indicator rated according to population of each district, mapped at the district scale across Bangkok, as displayed in the indicators portal. Acknowledgements: Indicators site: © RMIT University, 2021 (2021). | Indicator data: Department of Health, Bangkok Metropolitan Administration (2018). | District boundary data: Bangkok Metropolitan Administration (BangkokGIS). Retrieved 25 July 2019. | Map data: © OpenStreetMap contributors (https://www.openstreetmap.org/), CC-BY-SA (https://creativecommons.org/licenses/by-sa/2.0/). | The Tracking Progress site uses Sparkjoy GeoC WordPress Theme version 1.9, © Sparkjoy Studios, 2018. | The indicators portal is housed by the International Institute of Sustainable Development's Tracking Progress platform (https://www.tracking-progress.org/) with site development provided by Sparkjoy Studios (https://sparkjoy.com/). | The map displayed in the image above was created using Leaflet (https://leafletjs.com/) and imagery by Mapbox (https://www.mapbox.com/).

Results

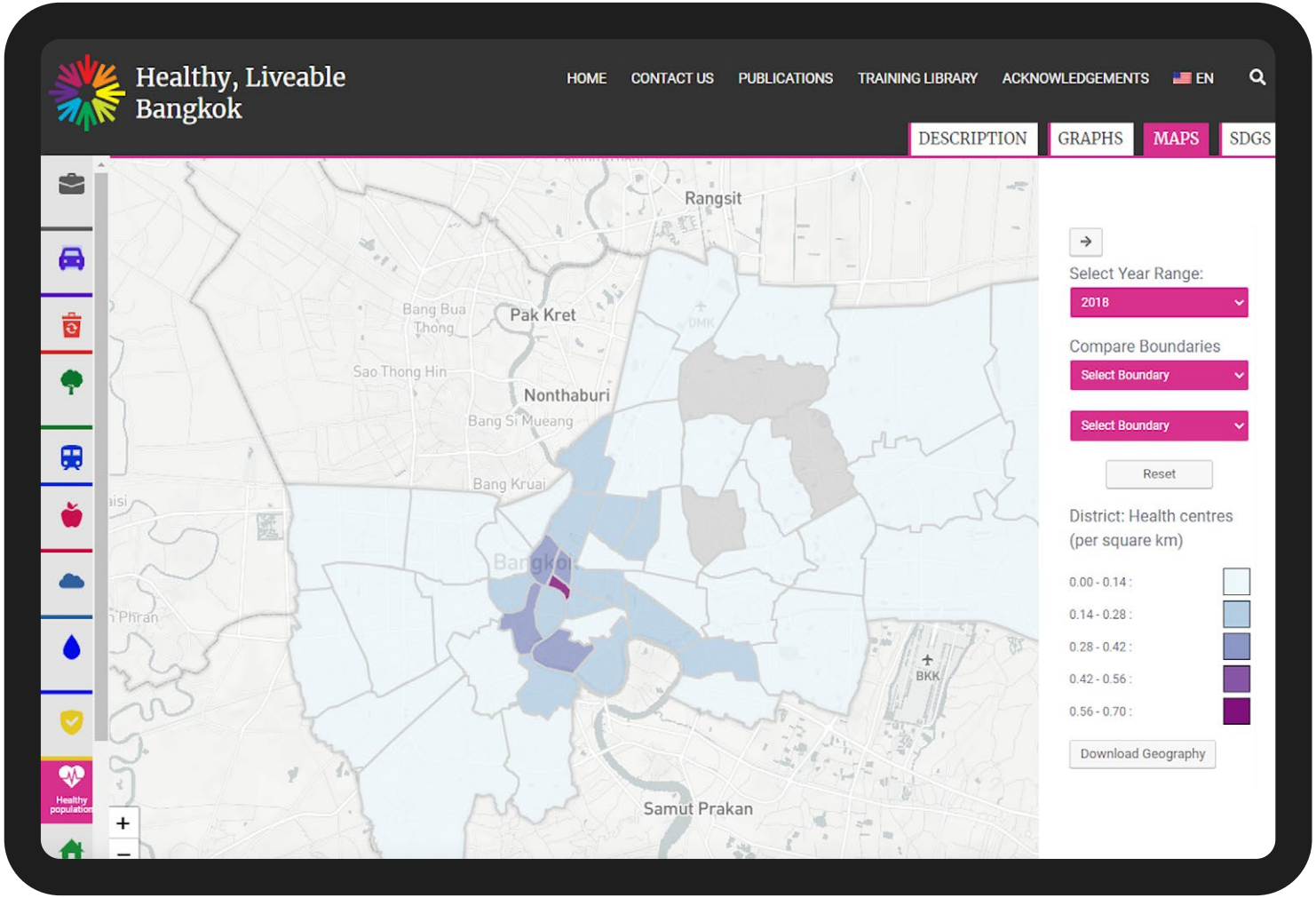


Figure 4. An example of a liveability indicator rated according to land area of each district, mapped at the district scale across Bangkok, as displayed in the indicators portal. Acknowledgements: Indicators site: © RMIT University, 2021 (2021). | Indicator data: Department of Health, Bangkok Metropolitan Administration (2018). | District boundary data: Bangkok Metropolitan Administration (BangkokGIS). Retrieved 25 July 2019. | Map data: © OpenStreetMap contributors (https://www.openstreetmap.org/), CC-BY-SA (https://creativecommons.org/licenses/by-sa/2.0/). | The Tracking Progress site uses Sparkjoy GeoC WordPress Theme version 1.9, © Sparkjoy Studios, 2018. | The indicators portal is housed by the International Institute of Sustainable Development's Tracking Progress platform (https://www.tracking-progress.org/) with site development provided by Sparkjoy Studios (https://sparkjoy.com/). | The map displayed in the image above was created using Leaflet (https://leafletjs.com/) and imagery by Mapbox (https://www.mapbox.com/).

Geographic areas of interest in Bangkok

The Bangkok Metropolitan Administration Working Groups selected three precincts in Bangkok for deeper exploration: Bang Phlat, Suan Luang, and Nong Chok. These three districts represented one inner-city, relatively higher population density district (Bang Phlat), one mid-city district (Suan Luang), and one outer-city, relatively lower population density district (Nong Chok). Bang Phlat was targeted for reducing inequities, and a substantial work program within the Bangkok Metropolitan Administration began in 2020 to explore liveability more deeply in this district. For example, a pilot project was initiated by the Strategy and Evaluation Department to improve liveability and quality of life in Bang Phlat through addressing key community-identified problems, such as damaged roads, waste management, and resilience to flooding and natural disasters. This pilot project became known as the Bang Phlat Model and has subsequently been expanded to other areas in Bangkok.

Capacity building outcomes, tools and resources

Following calculation of indicators, a package of output files was created comprising:

- **project documentation (metadata) and indicators concept guide:** a report in static PDF and interactive HTML formats, detailing the project background, methods, findings, outputs and technical directions for reproduction;
- **indicator maps** in PNG format;
- **indicator data tables** in CSV format containing linkage codes for districts and subdistricts, in a custom format for uploading into the indicators portal;
- **project geographies:** geojson boundaries for linkage, supporting the indicators portal;
- **calculated indicators:** a geopackage containing the indicators at district and subdistrict levels for direct mapping using QGIS;
- **distributional summary plots** annotated with key districts of interest (Bang Phlat, Nong Chok, and Suan Luang) in PDF and SVG format.

To complement these resources, tutorial video presentations (webinars) were prepared and recorded detailing the SUI software processing workflow, and demonstrations for how to use the generated data for preparing maps using QGIS, an open source geographic information systems software. Additional online webinars and presentations covered a list of topics identified by the Bangkok Metropolitan Administration as being important for capacity building, including:

- Overview of the key ideas and research connecting liveability and health
- Tour of the indicators portal site
- Project documentation and data processing to calculate indicators
- Uploading data and creating a new indicator
- Interpreting an indicator
- Indicators portal site customisation tutorials, developed by the International Institute of Sustainable Development

A library of training resources was developed to house the above webinars and tools in a ‘one-stop-shop’, in order to support ongoing and future capacity building activities within the Bangkok Metropolitan Administration.

In Bangkok, the Bangkok Metropolitan Administration led capacity building activities around understanding liveability and its connection to health through the Field and Strategic Action Working Groups. A Strategic Division Director began the engagement of district offices to train staff in measuring and monitoring liveability indicators. This work was paused in 2020 as resources were redirected to respond to COVID-19 outbreaks in Bangkok but is expected to resume in the long term.

Implications for Bangkok and Other Cities

Health Equity

Health Equity

Health equity has been at the forefront of this project's design, evidenced in both the liveability indicators themselves and the capacity building activities. First, indicators were calculated at district and subdistrict level because this allows policymakers and practitioners to identify geographic inequities (i.e., areas with gaps in infrastructure, poorer health outcomes, or both) within and across the city of Bangkok. Indeed, the Bangkok Metropolitan Administration Steering Committee's selection of Bang Phlat as a key geographic catchment of interest was motivated by the geographic inequities revealed through initial mapping and the aim of reducing inequities in Bangkok. Equity training was also built into capacity building activities. For example, the first webinar included an overview of how liveability relates to the concept of the social determinants of health – that is, the daily living conditions that impact on health.

Knowledge Translation

Knowledge Translation

Healthy Liveable Bangkok indicators portal

RMIT University and Bangkok Metropolitan Administration. (2021). Healthy Liveable Bangkok indicators portal [Online]. Available at: https://bangkokliveability.tracking-progress.org/

Software and project documentation

Higgs, C. (2021). Spatial Urban Indicators repository. Available at: https://bitbucket.org/carlhiggs/spatial-urban-indicators

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Webinars and training videos

Centre for Urban Research. (2020). Conceptualising and contextualising liveability for Bangkok. 9 September. Available at: https://www.youtube.com/watch?v=1dB8b4lmbEw&t=5s

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Mullett, J., et al. (18 February 2018). 'Achieving resilient, sustainable and healthy communities in the face of rapid urbanisation: Learning from Asia Pacific, South America and Africa.' United Nations Global Compact City Programme Side Event at the 2018 World Urban Forum, Kuala Lumpur.

Badland, H. et al. (30 June-5 July 2019). 'What is the meaning of urban liveability for a city in a low- to middle-income country? Contextualising liveability for Bangkok, Thailand.' International Medical Geography Symposium, Queenstown, New Zealand.

Pol. Gen. Aswin Kwangmuang, Governor of Bangkok. (7-10 July 2019). Presentation to the 2019 Asia Pacific Cities Summit and Mayors' Forum, Brisbane, Australia.

Badland, H., Alderton, A., and Higgs, C. (7 September 2020). 'Framing Bangkok's liveability through the SDGs.' School of Global, Urban and Social Studies Sustainable Development Goals Seminar, Melbourne, Australia.

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Alderton, A., et al. (3-6 September 2021). 'Translating urban health research in Bangkok: partnership framework for building capacity in monitoring liveability.' Poster session presented at: World Congress of Epidemiology, Melbourne, Australia.

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Davern, M., Roberts, R., and Higgs, C. (2018). Neighbourhood Liveability Assessment of Shepparton: The application of indicators as evidence to plan for a healthy and liveable regional city. RMIT University, Melbourne.

Davern, M., Roberts, R., and Higgs, C. (2018). Walkability in Tasmania: Assessment in the Local Government Areas of Brighton, Clarence and Launceston. RMIT University, Melbourne.

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Governor of Bangkok and Bangkok Metropolitan Administration delegation visit to RMIT University, Melbourne, Australia. (11 July 2019).

Project Outcomes

Project Outcomes

Project phase	Outcome	Degree achieved
Phase 1: Source spatial data for measuring liveability, aligned with the SDGs	Acquire appropriate open source datasets	Completely
Phase 2: Apply and test liveability indicators	Measure and map liveability indicators across Bangkok	Completely
	Specific geographic catchments to be identified by the Steering Committee for detailed examination	Completely
	Liveability indicators made available for ongoing use through web-based portal	Completely. The portal is currently set to private but will be publicly available pending final review and approval by the Bangkok Metropolitan Administration and Governor of Bangkok.
Phase 3: Capacity building	Three nominated staff from Bangkok Metropolitan Administration to take part in capacity building.	Amended, due to COVID-19 pandemic. Capacity building activities shifted to online format due to travel restrictions.
Phase 4: Generate translational outputs for future application	Liveability Monitoring Framework led and developed by Bangkok Metropolitan Administration.	Partially. A draft Liveability Monitoring Framework led by the Bangkok Metropolitan Administration has been developed. Implementation is expected to occur late 2021.
	Proof-of-concept framework using scalable and open source data for measuring progress towards liveability and achieving the SDGs.	Completely

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Appendix

Appendix A

The SUI workflow is configured using a multi-page Microsoft Excel workbook detailing project and study region parameters and indicators of interest. However, it was authored to be run through a Linux terminal (e.g. Ubuntu running on Windows Subsystem for Linux). Full details for installation of the computational environment, including set up of Windows Subsystem for Linux, is detailed in the project technical documentation (Bangkok Liveability Release 1.2) and accompanying video tutorial material (Healthy, Liveable Bangkok: Project documentation and set-up, and data cleaning).

Briefly, the SUI framework is installed as a self-contained Docker package (https://hub.docker.com/repository/docker/carlhiggs/ind_bangkok), and run in conjunction with a Postgresql and Postgis Docker container for spatial database management. Docker provides a stable way of packaging and disseminating software, to ensure dependencies are met and broad compatibility with a range of computing platforms.

The workflow is executed as a series of Python 3 scripts which are run sequentially, or at any time to consolidate progress to-date. These are executed by defining the parameters in the accompanying project configuration Excel workbook, and then executing code for the corresponding study region using the format:

python <workflow_script>.py <study region name>

Therefore, for Bangkok, the first script run is:
python 00_create_database.py bangkok.

The sequential scripts are:

00_create_database.py

01_create_study_region.py

02_create_population.py

03_create_osm_resources.py

04_create_network_resources.py

05_open_space_areas_setup.py

06_create_sample_points.py

07_compile_destinations.py

08_accessibility_analysis.py

The consolidation scripts are:

_create_linkage_indicators.py

_create_raster_indicators.py

_export_indictor_csv_list.py

_generate_attributions.py

_render_plots.py

_create_accessibility_indicators.py

_create_documentation.py

Details around the usage of each of these scripts is provided in the project documentation.

Appendix B

Purpose of dataset	Dataset alias	Attribution
Bangkok boundaries	Bangkok subdistrict boundaries (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University 2019-20. | Data: "Bangkok subdistrict boundaries", BangkokGIS (BMA) (2018).
Population	Population (BMA, 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Bangkok subdistrict population (BMA, 2019)", BMA (2019).
Destinations	Bus stations [BRT express bus station in Bangkok area]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: bus stations", BangkokGIS (BMA) (2014).
Destinations	Ferry ports [Boat Quay in the Chao Phraya River in Bangkok]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University 2019-20. | Data: "Public transport: ferry ports", BangkokGIS (BMA) (2018).
Destinations	Ferry ports [Canal Sansabai]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: ferry ports", BangkokGIS (BMA) (2014).
Destinations	Any public open space entry points (OpenStreetMap, 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public open space", OpenStreetMap Contributors (2019).
Destinations	Large public open space entry points (OpenStreetMap, 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public open space", OpenStreetMap Contributors (2019).
Destinations	Public transport (any; OpenStreetMap)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport", OpenStreetMap Contributors (2019).
Destinations	Supermarket (OpenStreetMap)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Supermarket access", OpenStreetMap Contributors (2019).
Destinations	Train stations [Airport Rail Link (ARL)]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: train stations", BangkokGIS (BMA) (2014).
Destinations	Train stations [Bangkok Mass Transit System (BTS) in Bangkok]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: train stations", BangkokGIS (BMA) (2014).
Destinations	Train stations [Chaloem Ratchamongkhon MRT Station in Bangkok]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: train stations", BangkokGIS (BMA) (2014).
Destinations	Train stations [Railway Station / Stop at Bangkok Railway Station]	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport: train stations", BangkokGIS (BMA) (2014).

Purpose of dataset	Dataset alias	Attribution
Indicators	Fire incidence (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Fire incidence in Bangkok, 2018", Department of Fire and Rescue, BMA (2019).
Indicators	Number of locations with reported crime (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Risk areas: Number of locations with reported crime", Department of City Law Enforcement, BMA (2019).
Indicators	Number of locations with reported road accidents (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Risk areas: number of locations with reported road accidents", Department of City Law Enforcement, BMA (2019).
Indicators	Air quality monitoring stations (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Monitoring stations (PCD, 2019)", Thai Pollution Control Department (2019). Available at: http://air4thai.pcd.go.th
Indicators	Annual average NO2 (1-e6 mmol/m^2; 2017-18)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University 2019-20. | Data: "Annual average Sentinel-5P NRTI NO2: Near Real-Time Nitrogen Dioxide (13 October 2017 - 12 October 2018)". Copernicus Sentinel Data processed using Google Earth Engine.
Indicators	Number of days PM 2.5 exceeds Thai standard (50 µg/m^3; January 2019, PCD)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of days PM 2.5 exceeds Thai standard (50 µg/m^3; January 2019, PCD)", Thai Pollution Control Department (2019).
Indicators	Number of days PM 2.5 exceeds WHO standard (25 µg/m^3; January 2019, PCD)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of days PM 2.5 exceeds WHO standard (25 µg/m^3; January 2019, PCD)", Thai Pollution Control Department (2019).
Indicators	Average days of flooding (main road flood areas; 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Average days of flooding across 14 main road flood areas of Bangkok, 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Average days of rain (main road flood areas; 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Average days of rain across 14 main road flood areas of Bangkok, 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Average maximum intensity (main road flood areas; 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Average maximum intensity across 14 main road flood areas of Bangkok, 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Main road flood area location count (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Main road flood area location count of Bangkok, 2018", Department of Drainage and Sewerage, BMA (2019).

Purpose of dataset	Dataset alias	Attribution
Indicators	Vulnerable flood area count (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University 2019-20. | Data: "Vulnerable flood area count for Bangkok, 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Number of main road of traffic jams (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Traffic jam", BMA, sourced from: https://www.grandprix.co.th/10 (Accessed 25 September 2019) (2019).
Indicators	Canal water storage BOD (mg/L; 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Canal water storage BOD (mg/L), 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Canal water storage BOD < 6 mg/L (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Canal water storage BOD (mg/L), 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Canal water storage DO (mg/L; 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Canal water storage DO (mg/L), 2018", Department of Drainage and Sewerage, BMA (2019).
Indicators	Canal water storage sample locations (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Canal water storage sample locations", Department of Drainage and Sewerage, BMA (2019).
Indicators	Annual hazardous waste (kg, 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Hazardous waste: annual hazardous waste", Department of Environment, BMA (2019).
Indicators	Annual recyclable waste (tonnes, 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Solid waste: annual recyclable waste", Department of Environment, BMA (2019).
Indicators	Annual solid waste (tonnes, 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Solid waste: annual solid waste", Department of Environment, BMA (2019).
Indicators	Percentage hazardous waste (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Hazardous waste: percentage hazardous waste", Department of Environment, BMA (2019).
Indicators	Percentage recyclable waste (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Solid waste: percentage recyclable waste", Department of Environment, BMA (2019).
Indicators	Number of museums (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA libraries and museums", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Number of sport centres (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: number of sport centres", Department of Culture, Sports and Tourism, BMA (2018).

Purpose of dataset	Dataset alias	Attribution
Indicators	Number of sport yards (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: number of sport yards", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Number of temples (2014)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA Places of worship", Buddhism Division, National Buddhism Office; BMA district offices (2019).
Indicators	Number of youth centres (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: number of youth centres", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Visits to sport centres (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: visits to sport centres", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Visits to sport yards (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: visits to sport yards", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Visits to youth centres (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA youth centres: visits to youth centres", Department of Culture, Sports and Tourism, BMA (2018).
Indicators	Average age (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Population by age groups", Department of Provincial Administration, Ministry of Interior (BMA) (2018).
Indicators	Average age (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Population by age groups", Department of Health, BMA (2018).
Indicators	Health centres (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Health centres", Department of Health, BMA (2018).
Indicators	Diabetes outpatients (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Outpatient numbers for diabetes of 68 Health Centres", Department of Health, BMA (2018).
Indicators	Hypertension outpatients (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Outpatient numbers for hypertension of 68 Health Centres", Department of Health, BMA (2018).
Indicators	Mental and behavioural disorder outpatients (2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Outpatient numbers for mental and behavioural disorders of 68 Health Centres", Department of Health, BMA (2018).
Indicators	Average National General Education (O-NET) score for BMA primary schools (2016)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "O-Net in BMA schools", Department of Education, BMA (2019).

Purpose of dataset	Dataset alias	Attribution
Indicators	Number of primary schools (2016)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "BMA school locations", Department of Education, BMA (2019).
Indicators	Number of holders of a state welfare card in Bangkok (2017)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Welfare card holders", BMA (2017).
Indicators	Number of registered farmer households expected to be impacted by drought (2016)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Drought impact", BMA (2015).
Indicators	Average monthly cost of living per person (Baht; 2017)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Poverty Indicators 2017", National Statistical Office (2018).
Indicators	Food quality tests (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Food quality tests", Department of Health, BMA (2019).
Indicators	Number of hawkers/stalls (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Sidewalk hawkers: Number of hawkers/stalls", Department of City Law Enforcement, BMA (2019)
Indicators	Number of markets (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of markets (BMA, 2019)", Department of Environment and Sanitation, BMA (2019).
Indicators	Number of minimarts (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of minimarts (BMA, 2019)", Department of Environment and Sanitation, BMA (2019).
Indicators	Number of restaurants (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of restaurants (BMA, 2019)", Department of Environment and Sanitation, BMA (2019).
Indicators	Number of food stalls (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of stalls (BMA, 2019)", Department of Environment and Sanitation, BMA (2019).
Indicators	Number of supermarkets (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Number of supermarkets (BMA, 2019)", Department of Environment and Sanitation, BMA (2019).
Indicators	Percentage of residents living 800 metres distance of a supermarket (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Supermarket access", OpenStreetMap Contributors (2019).
Indicators	Permitted sidewalk hawker/stall locations (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Sidewalk hawkers: permitted sidewalk hawker/stall locations", Department of City Law Enforcement, BMA (2019).

Purpose of dataset	Dataset alias	Attribution
Indicators	Vital diseases (combined, 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Vital diseases", Department of Health, BMA (2019).
Indicators	Percentage of residents living within 400 metres of large public open space (1.5 hectares or larger; 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public open space", OpenStreetMap Contributors (2019).
Indicators	Percentage of residents living within 400 metres of public open space (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public open space", OpenStreetMap Contributors (2019).
Indicators	Enhanced Vegetation Index (EVI, annual mean; 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "MYD13Q1: MODIS/Aqua Vegetation Indices 16-Day L3 Global 250 m SIN Grid V006", Landsat-8 data courtesy of the U.S. Geological Survey, processed using Google Earth Engine (2020). Available at: https://dds.cr.usgs.gov/
Indicators	Normalised Difference Vegetation Index (NDVI, annual mean; 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "MYD13Q1: MODIS/Aqua Vegetation Indices 16-Day L3 Global 250 m SIN Grid V006", Landsat-8 data courtesy of the U.S. Geological Survey, processed using Google Earth Engine (2020). Available at: https://dds.cr.usgs.gov/
Indicators	Vegetation Percent (mean; December 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Fraction of Vegetation Cover (average percentage; V2, 1km)", Copernicus Service Information (2019). Available at: https://land.copernicus.eu/global/products/fcover
Indicators	Vegetation Percent (mean; December 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Fraction of Vegetation Cover (standard deviation percentage; V2, 1km)", Copernicus Service Information (2019). Available at: https://land.copernicus.eu/global/products/fcover
Indicators	Vegetation Percent (standard deviation; December 2018)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Fraction of Vegetation Cover", Copernicus Service Information (2019). Available at: https://land.copernicus.eu/global/products/fcove
Indicators	Number of green areas (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Green areas", BMA (2019).
Indicators	Total public green area per capita (m^2; 2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Green areas", BMA (2019).
Indicators	Total public green area percent (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Green areas", BMA (2019).
Indicators	Percentage of residents living 800 metres distance of any public transport (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: "Public transport", OpenStreetMap Contributors (2019).

Purpose of dataset	Dataset alias	Attribution
Indicators	Percentage of residents living within 800 metres of a ferry terminal or pier (2014)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: “Public transport”, BangkokGIS (BMA) (2014).
Indicators	Percentage of residents living within 800 metres of a train station (2014)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). Data: “Public transport”, BangkokGIS (BMA) (2014).
Indicators	Percentage contribution of local taxes to overall BMA tax revenue (2019)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: “Taxes collected”, Department of Finance, BMA (2019).
Indicators	Coefficient of inequality (2017)	Bangkok Metropolitan Administration (BMA) and Centre for Urban Research, RMIT University (2019-20). | Data: “Poverty Indicators 2017”, National Statistical Office (2018).

Final Research Report

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