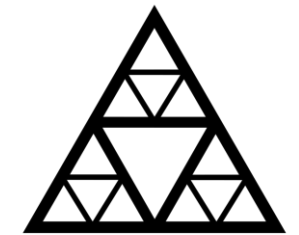
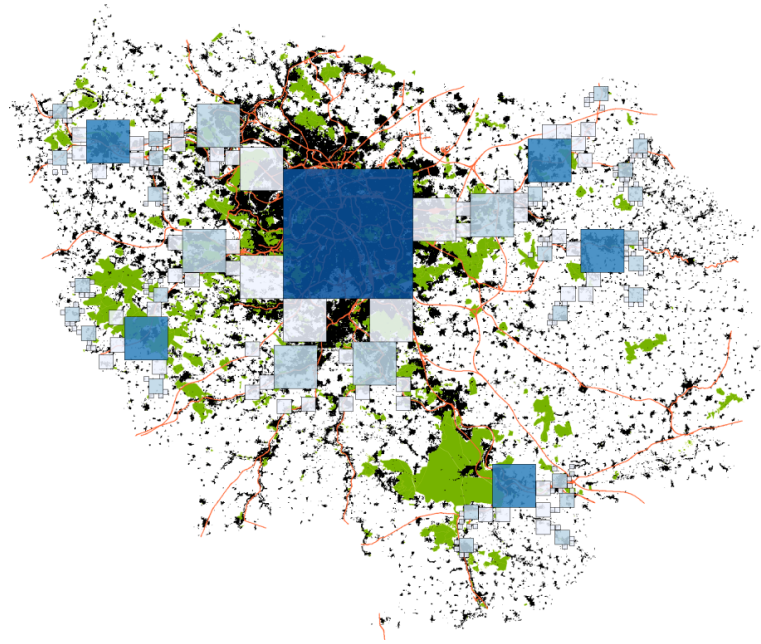
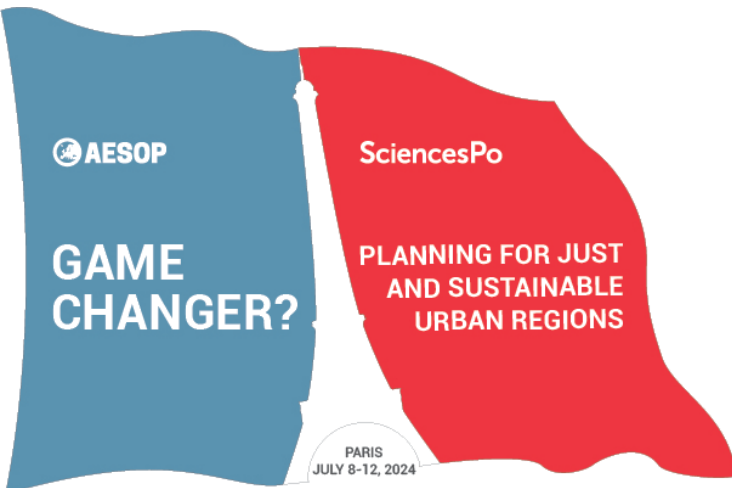


Repositioning The 15-Minute City Concept In A Multi-Scale Spatial Reading : The Contributions Of The Fractalopolis Methodology



École des Ponts
ParisTech

Xavier Lehmann¹, Pierre Frankhauser², Olivier Bonin¹

1 - LVMT, Univ Gustave Eiffel, ENPC, Champs-sur-Marne, France

2 - Laboratoire ThéMA, Univ de Franche-Comté, Besançon, France

July 8-12, 2024, Paris

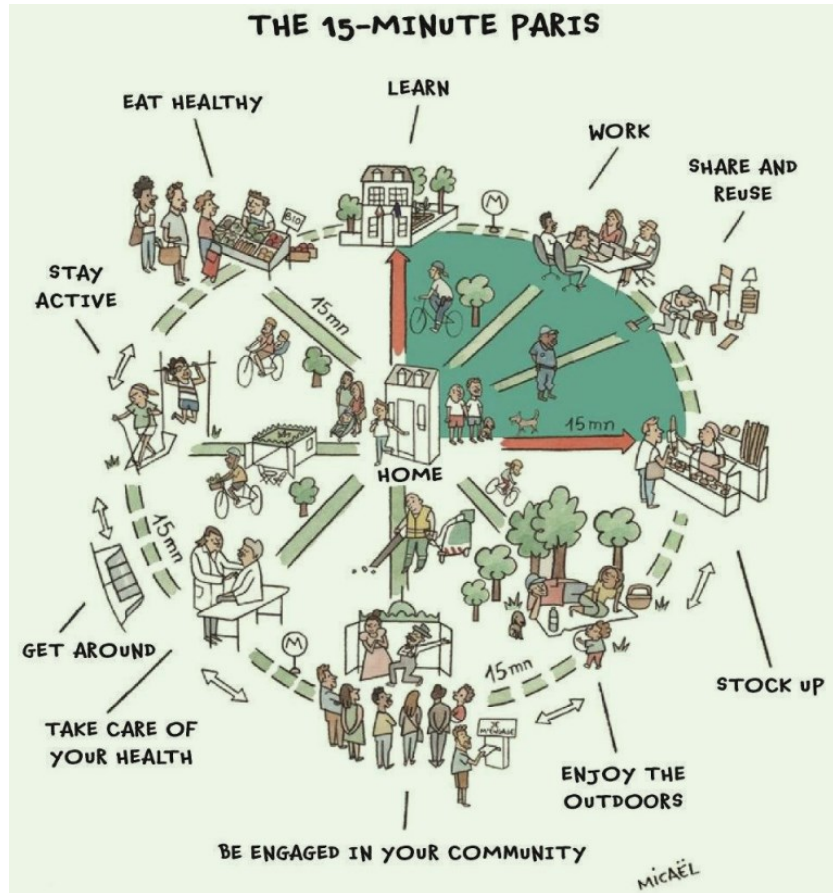
ThéMA
UMR 6049 Théoriser & Modéliser pour Aménager

**UNIVERSITÉ DE
FRANCHE-COMTÉ**

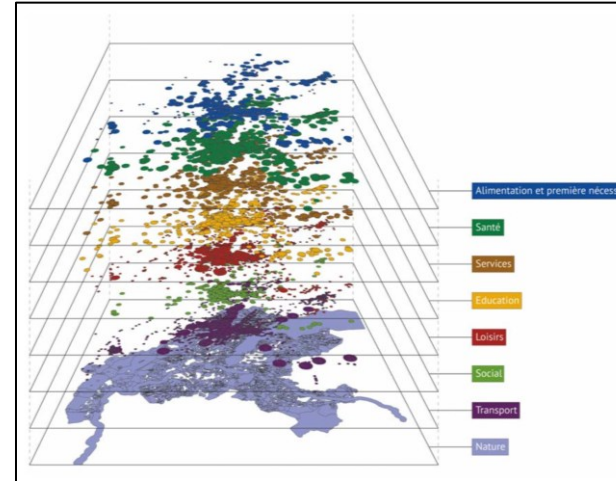
LVMT Laboratoire
Ville
Mobilité
Transport

**Université
Gustave Eiffel**

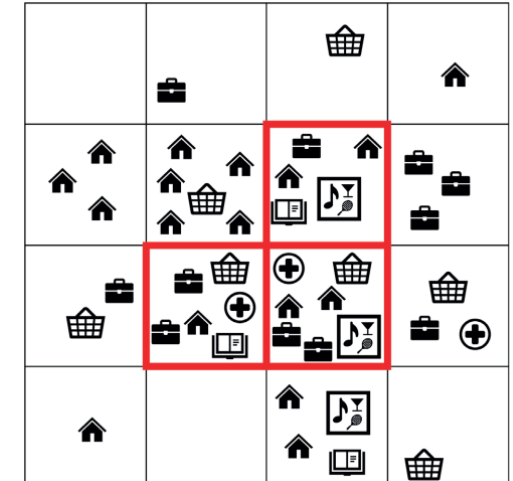
New concepts and tools to assess proximity accessibility of territories



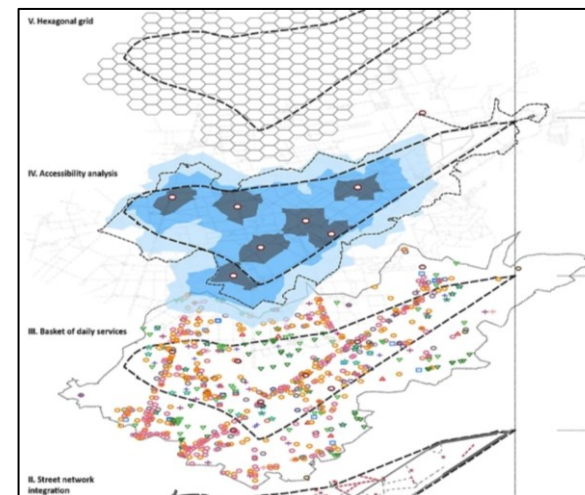
Paris en commun, Micael - Urban Mobility Next 9, EIT Urban Mobility Munich, 2022



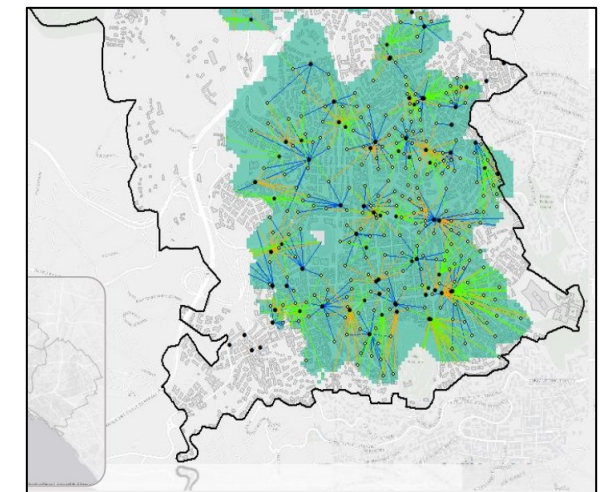
6t-bureau de recherche, Territoire des courtes distances, 2022



Aupa., La ville des courtes distances, 2022

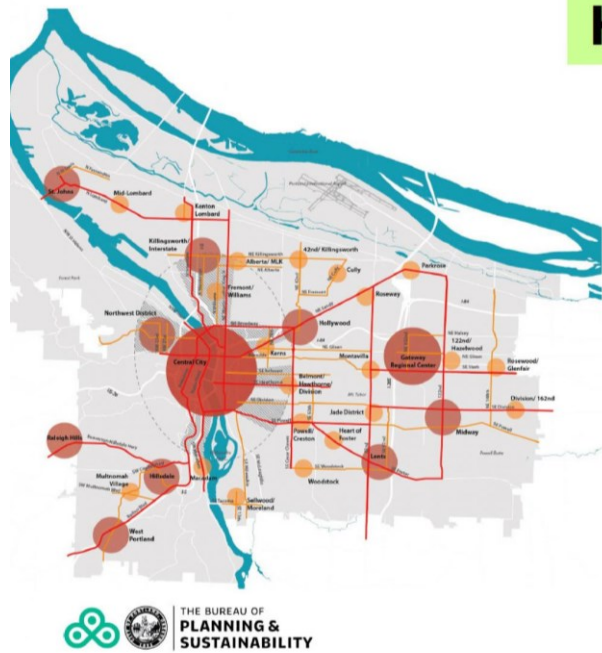


Lanza, L. C., Paola Pucci, Giovanni., IAP Index, 2022



Gaglione, F., Gargiulo, C., & Zucaro, F., Service area analysis, 2023

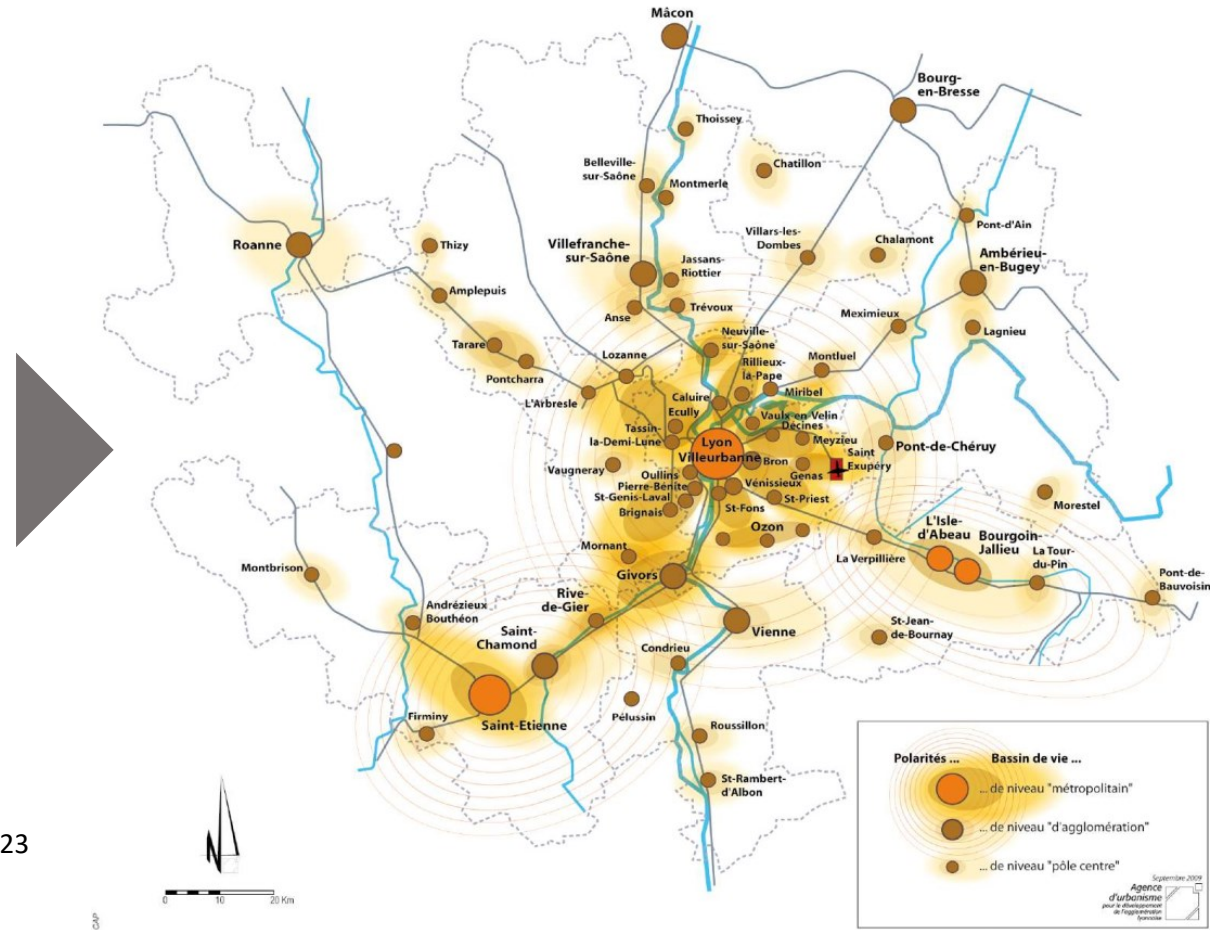
Challenges of multi-scale analysis for spatial planning



Hierarchy of Centers



R. Steuteville, Hierarchy of centers for the 15-minute city – City of Portland, www.cnu.org, 2023

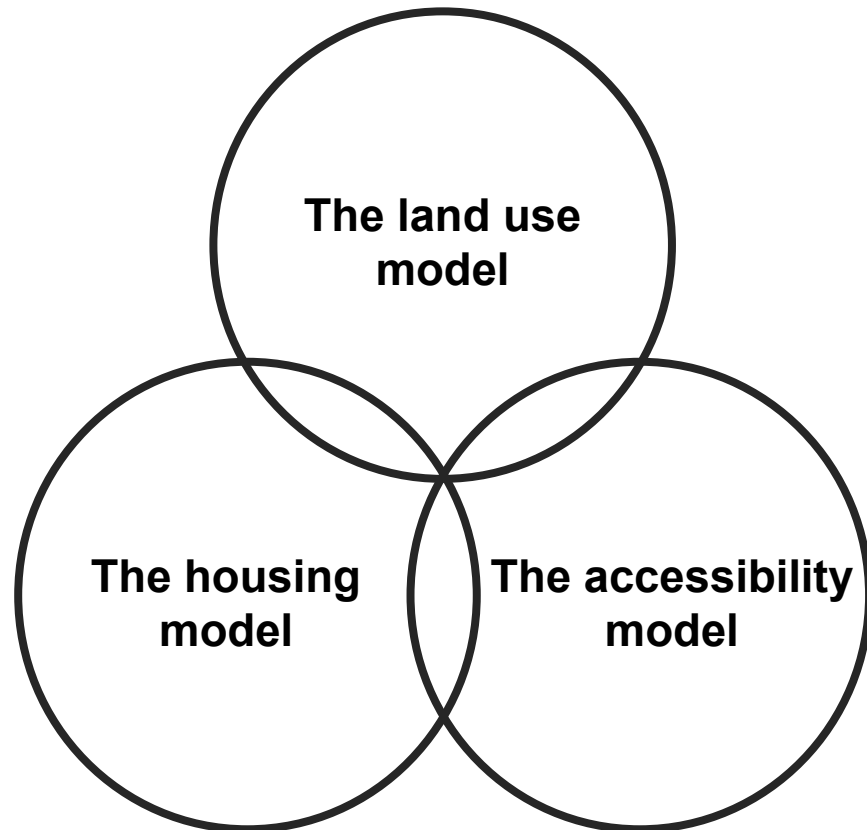


URBALYON, 2009, *L'inter-Scot de l'aire métropolitaine lyonnaise*.

The Fractalopolis software

<https://sourcesup.renater.fr/www/fractalopolis/> : Open source software of spatial simulation (Java version) by P. Frankhauser, O. Bonin, G. Vuidel, C. Yamu.

Three modelling entries



Goals of the Fractalopolis concept

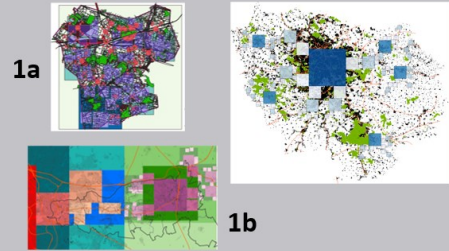
- Respects the **hierarchy of needs**
 - by a **hierarchical organization of "urban" amenities**
 - ensuring **good accessibility to amenities** according to the hierarchical levels, **reduces car use and trip lengths**
- Preserves biodiversity and avoids heat islands** by
 - a **linked hierarchical system of green areas** avoiding their fragmentation and that of urbanized areas
 - a **good accessibility** to the different types leisure areas
 - **the green corridors across scales** for **cooling** urbanized areas
 - allowing to install **suburban agriculture**
- Prioritize the public transportation**

The Fractalopolis software

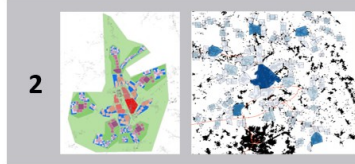
<https://sourcesup.renater.fr/www/fractalopolis/> : open source software of spatial simulation (Java version) by P. Frankhauser, O. Bonin, G. Vuidel, C. Yamu.

French context

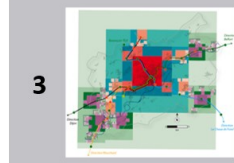
Metropolitan scale : **Ile-de-France Region** / Local scale :
1a - **Est-Ensemble**, O. Bonin et al., 2020
2b – **Marne-La-Vallée**, X. Lehmann, 2023



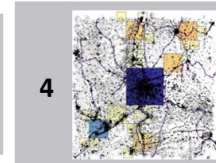
Metropolitan scale : **Pôle métropolitain Nord Franche-Comté** / Local scale : **Belfort**
X. Lehmann, 2024



Metropolitan scale : **Grand Besançon Métropole** / Local scale : **Besançon**.
J.-P. Antoni et al., 2014

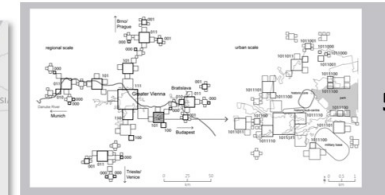


Metropolitan scale : **Lyon conurbation**
P. Frankhauser, 2012



International applications

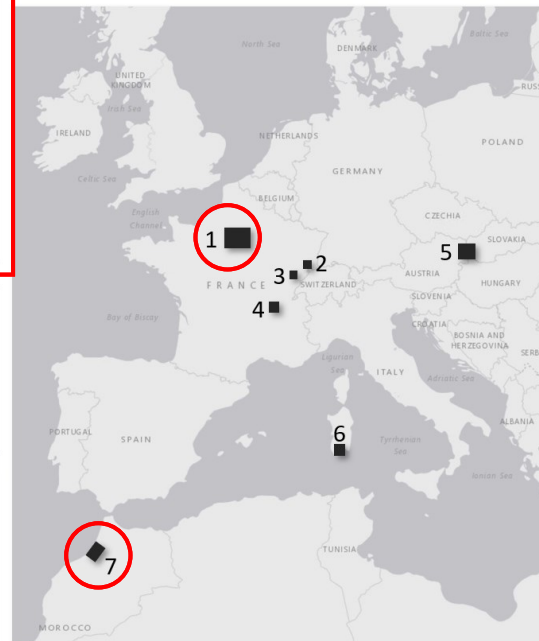
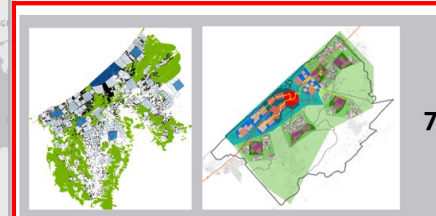
Metropolitan scale : **Vienna-Bratislava metropolitan area** / Local scale : **Bruck an der Leitha**
C. Yamu, P. Frankhauser, 2015



Metropolitan scale : **Sardinia** / Local scale : **Cagliari**
C. Garau, P. Frankhauser, 2024



Metropolitan scale : **Rabat-Salé-Skhirat-Témara conurbation**
Local scale : **Rabat-Salé**
X. Lehmann, 2024



The Fractalopolis methodology



1. Analysis of urban planning documents

- Understand the various development issues in the area of application, at different scales
- Understand the organisation of the urban and commercial structure



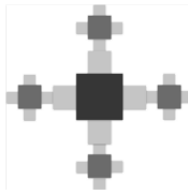
2. Understanding the needs and practices of the population

- Mobility practices and use of amenities, access distances by type of amenity
- Select the shops and services to be used for accessibility measures



3. Building the database

- Land use data (buildings, green spaces)
- Population distribution and geolocation of amenities



4. Fractalopolis project

- Development of a multi-scale zoning system
- Satisfaction for zones

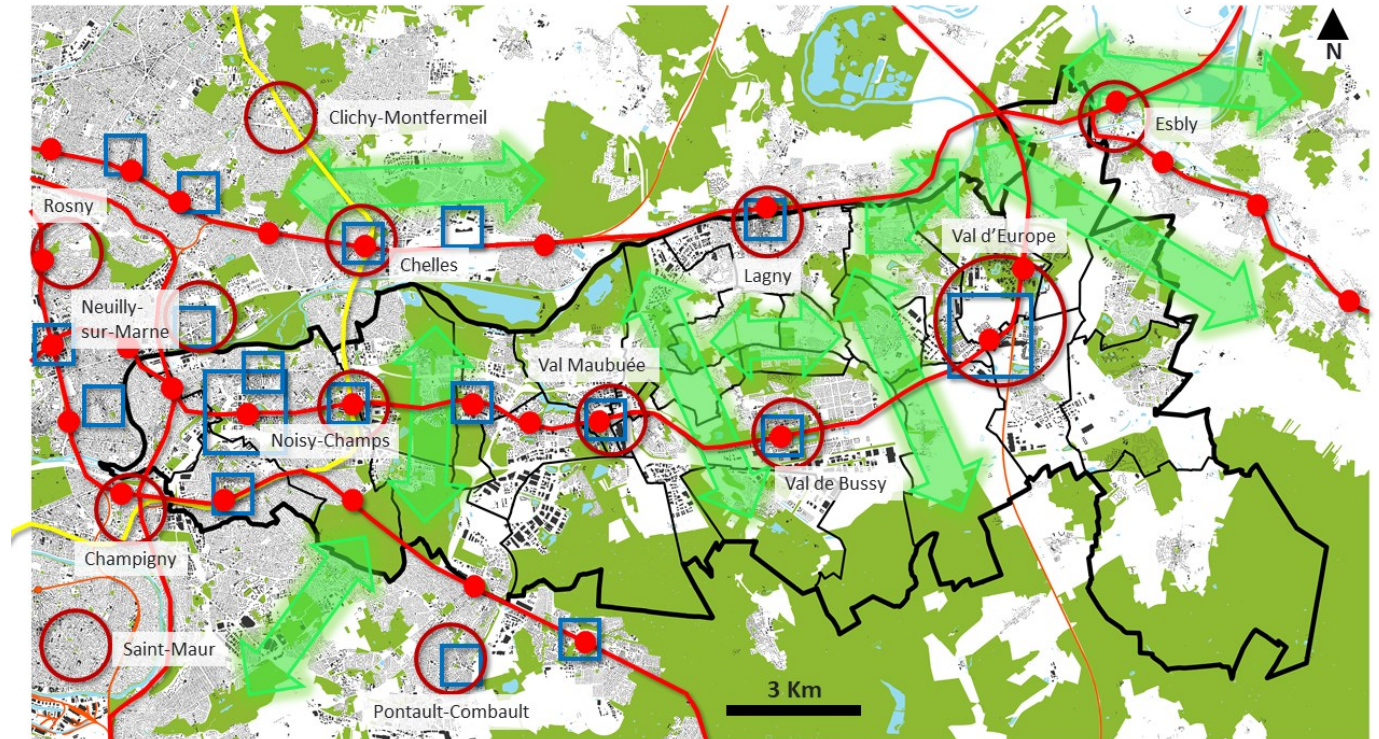
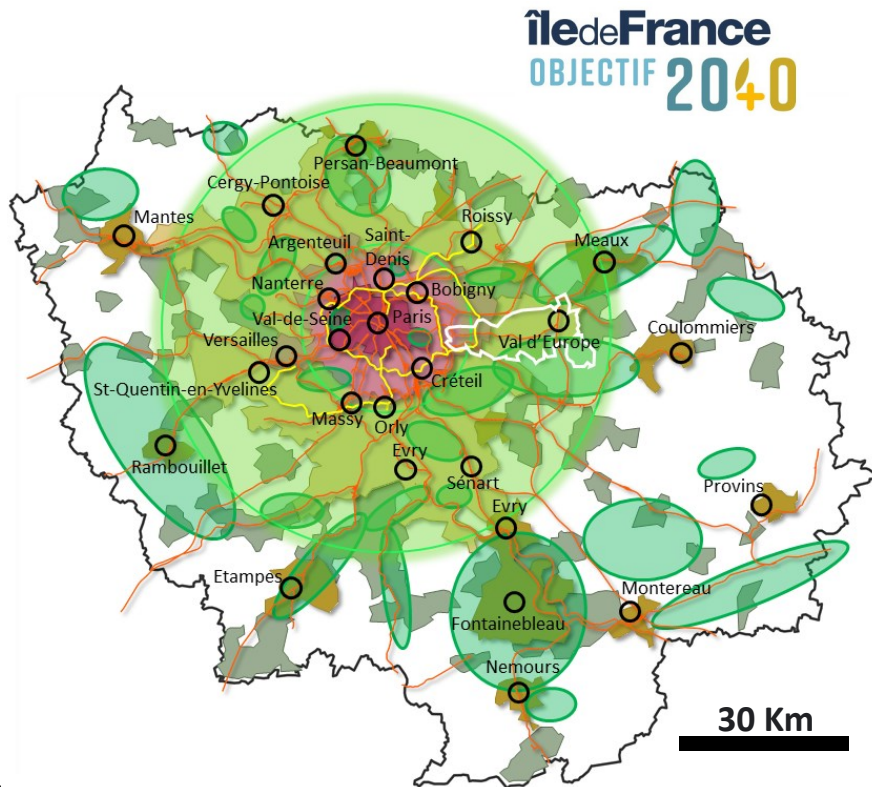


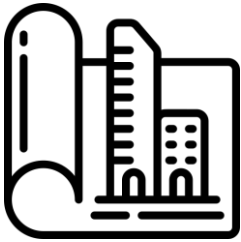
1. Analysis of urban planning documents

Marne-la-Vallée (The Greater Paris Metropolis, Ile-de-France Region)

New town territory, TOD principle, strong polarization by some amenities: university, train stations, motorways, shopping malls, etc. Based on the 15min city and 20min territory

- 1
- +
- 2
- +
- 3
- ▼
- 4

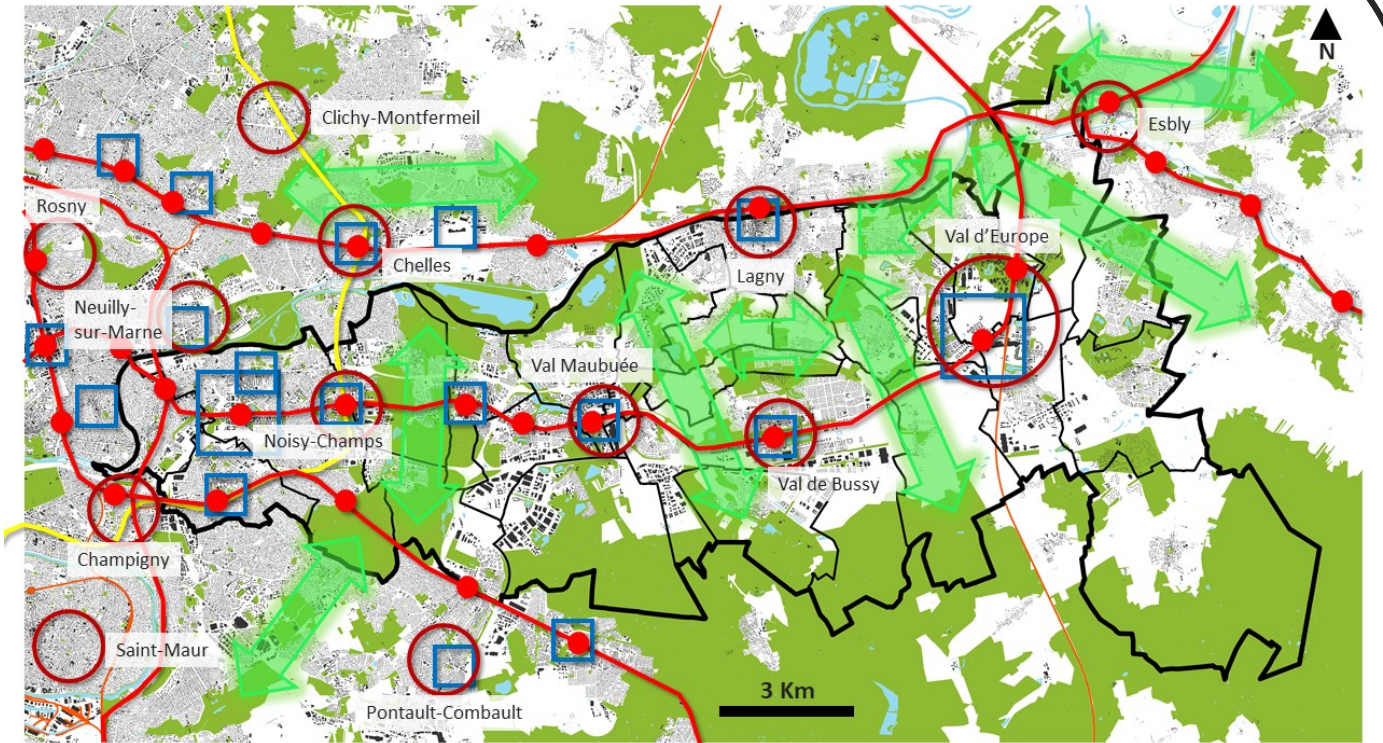
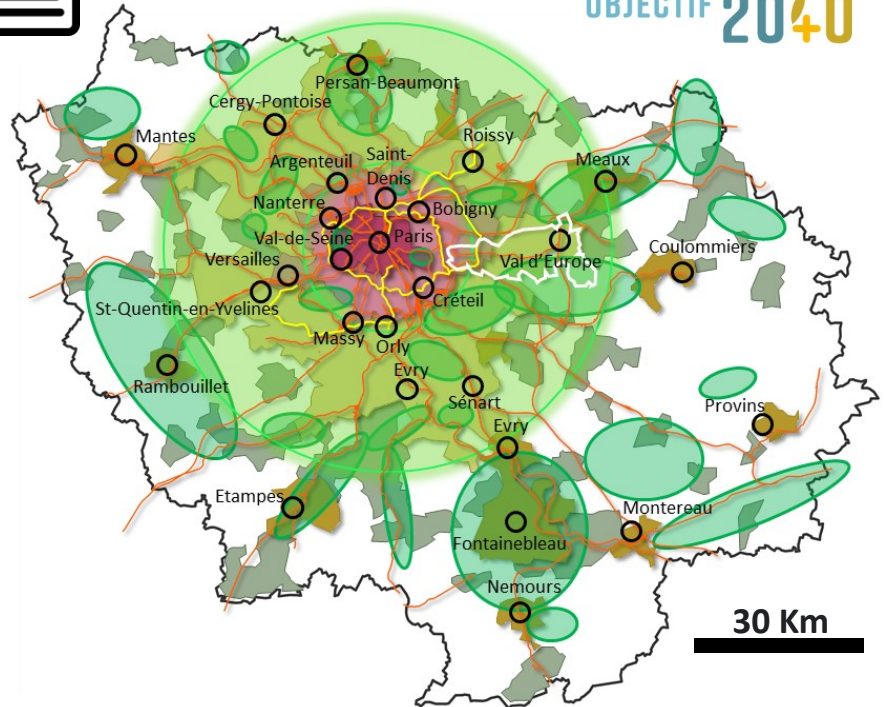




Île de France

OBJECTIF 2040

- 1
- +
- 2
- +
- 3
- ▼
- 4



- The hypercentre
 - The « heart »
 - The « crown »
 - Medium-sized towns
 - Small towns
 - Main urban centres
- } Dense urban area
- Rail network (trains and RER)
 - Grand Paris Express (under construction)
 - Main biodiversity reservoirs
 - Green belt (agricultural and woodland corridors)

- Buildings
 - Green spaces (forests, parks, gardens, etc.)
 - Hydrographic elements
 - Main urban centres
 - Main commercial centres
 - Secondary commercial centres
 - Administrative boundaries (communes)
- Train stations
 - Grand Paris Express (under construction)
 - Main ecological corridors to preserve

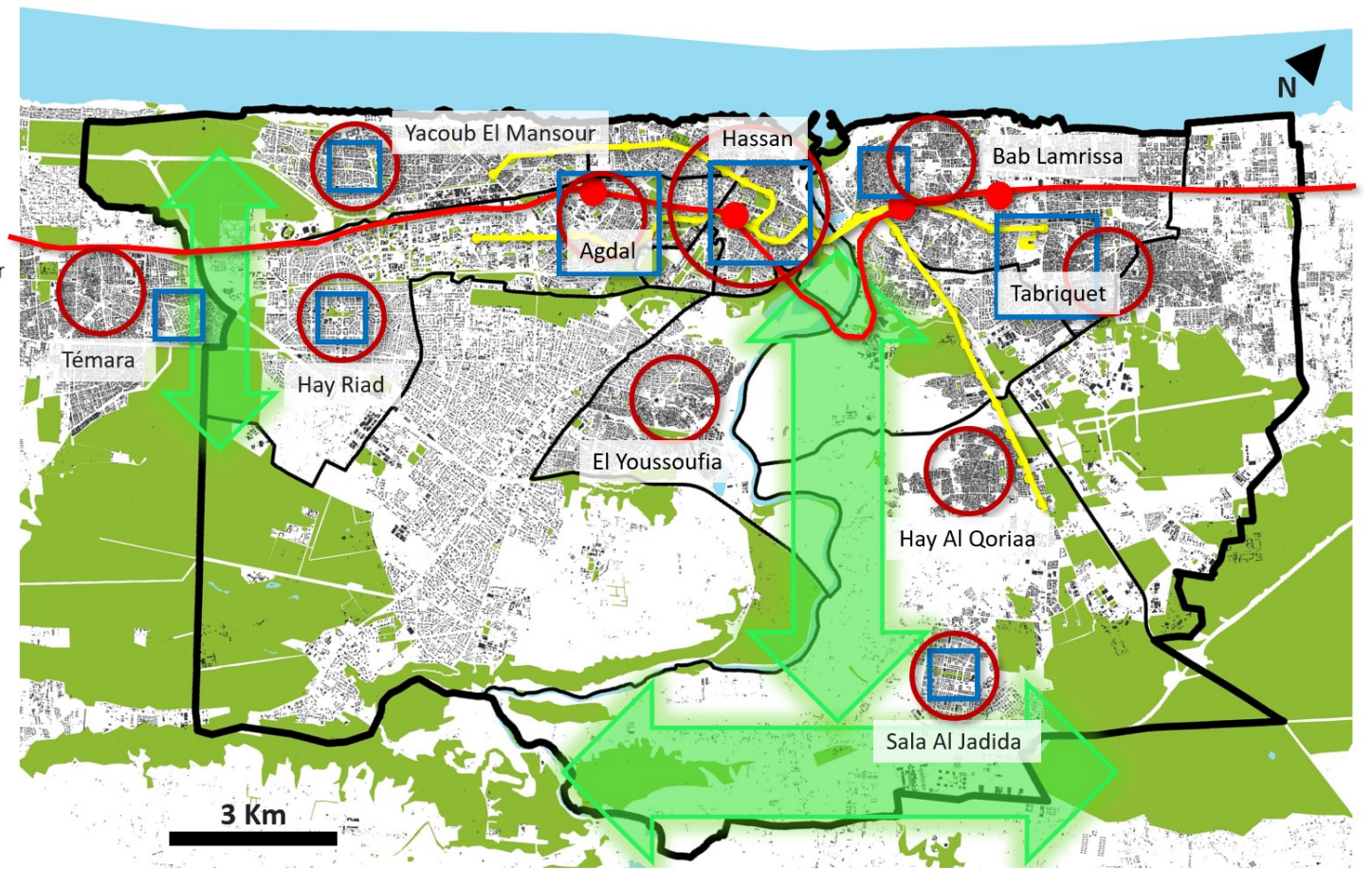
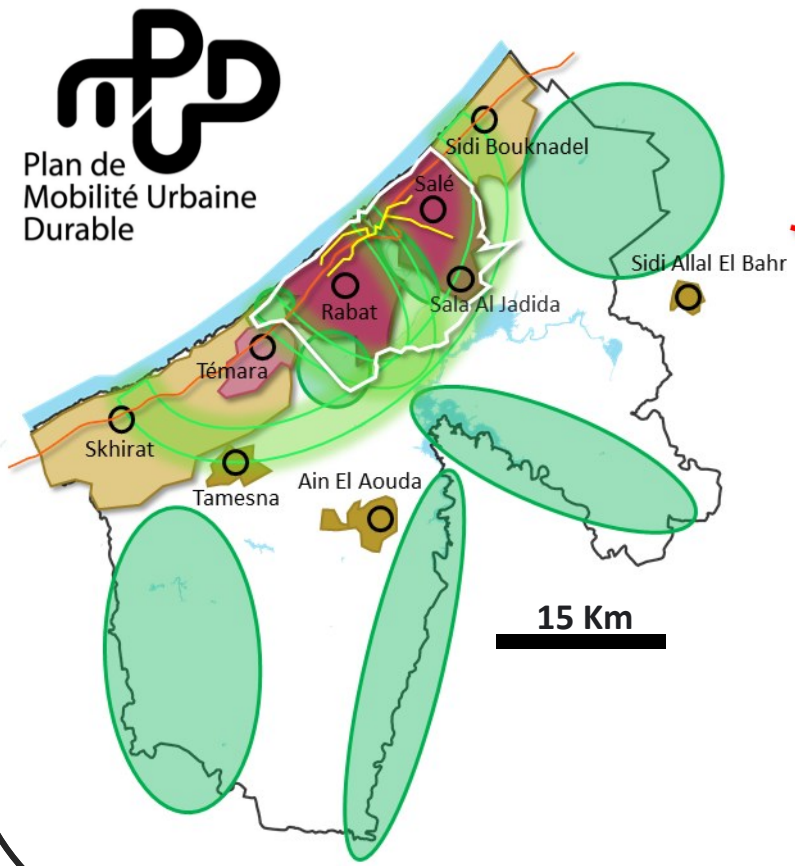


1. Analysis of urban planning documents

Rabat-Salé urban area (Rabat-Salé-Skhirat-Témara conurbation)

Dense urban centre (Medina), neighbourhoods with unregulated urbanisation (shantytowns), structured tramway network, major river valley and green belt.

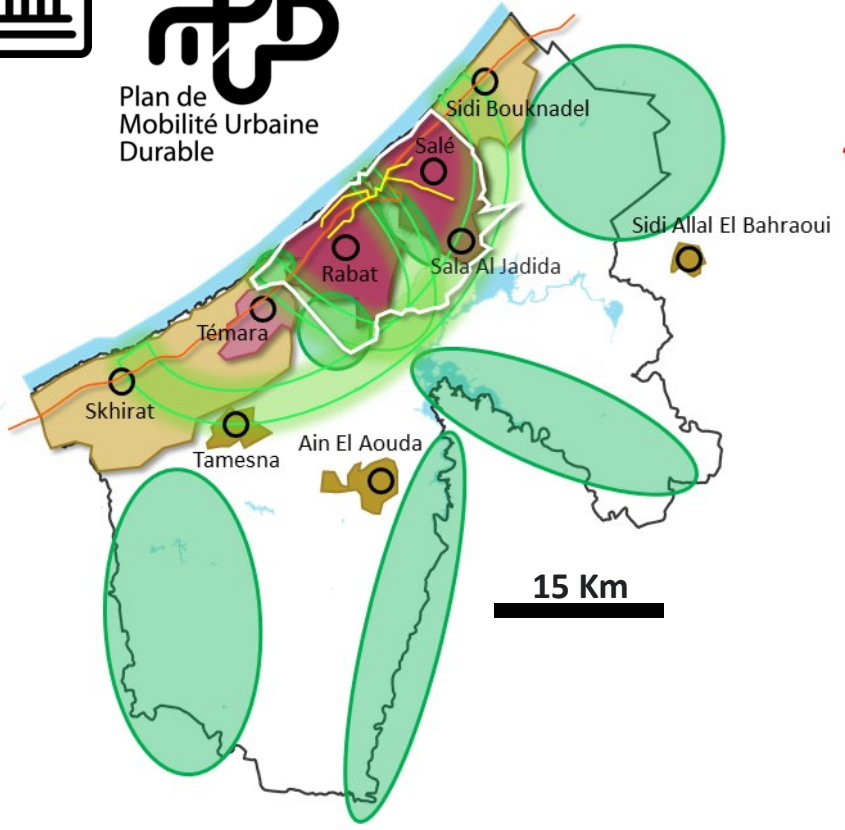
- 1
- +
- 2
- +
- 3
- ▼
- 4



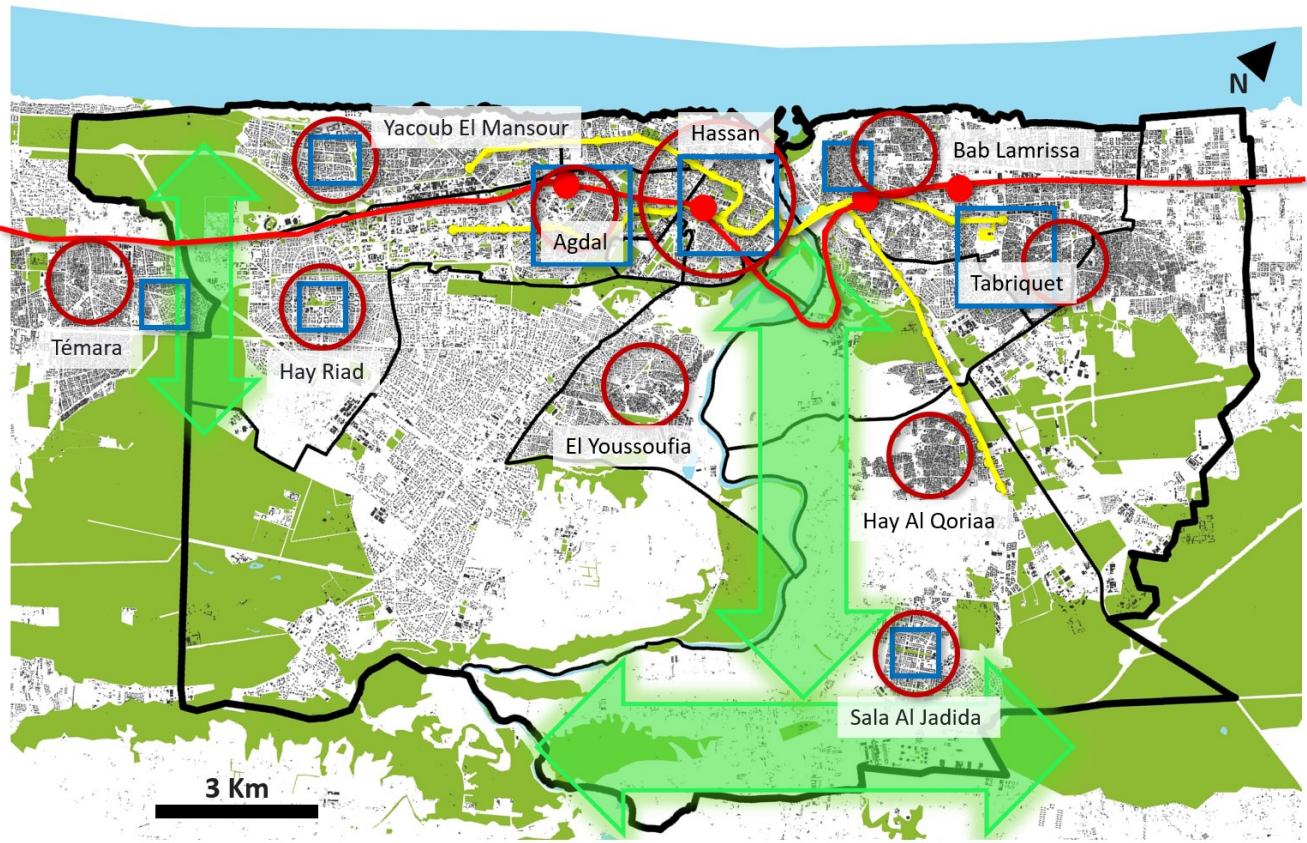


Plan de
Mobilité Urbaine
Durable

- 1
- +
- 2
- +
- 3
- ▼
- 4



- The hypercentre
- The « heart » (Rabat-Salé-Témara)
- Main coastal conurbation
- New towns and small cities
- Main urban centres
- Rail network
- Rabat-Salé tramway
- Main biodiversity reservoirs
- Green belt (agricultural and woodland corridors)



- Buildings
- Green spaces (forests, parks, gardens, etc.)
- Hydrographic elements
- Main urban centres
- Main commercial centres
- Secondary commercial centres
- Rail network (trains)
- Train stations
- Rabat-Salé tramway
- Main ecological corridors to preserve
- Administrative boundaries (arrondissements)



1. Analysis of urban planning documents

- References

Ile-de-France Region

- Schéma directeur de la région Île-de-France environnemental (SDRIF-E) 2040
 - IPR report on Greater Paris, 2021
 - INSEE data (Bassins de vie)
- Geoportal of the « Observatoire des territoires »



Rabat-Salé-Témara Conurbation

- Plan de Mobilité Urbaine Durable (PMUD) 2040
- SOAP de Rabat-Salé-Skhirat, 2011
- SDAU 2040 Rabat-Salé-Témara, 2015 (inachevé)
- Rabat-Salé Urban Agency documents

Marne-la-Vallée

- SCoT de Marne et Gondoire, 2020
- PLUI Grand Paris Grand Est, 2021
 - PLU communaux
 - ANCT and INRAE studies on centralities, 2020
- Atlas of city centres, FNAU, 2023



Rabat - Salé

- APUR study to draw up unified development plans for Rabat and Salé, 2009
- Architecture and urban planning student projects (INAU et ENA de Rabat)
- Rabat-Salé Urban Agency Geoportal

1

+

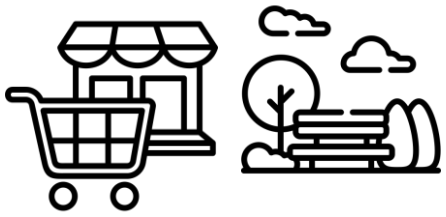
2

+

3

▼

4

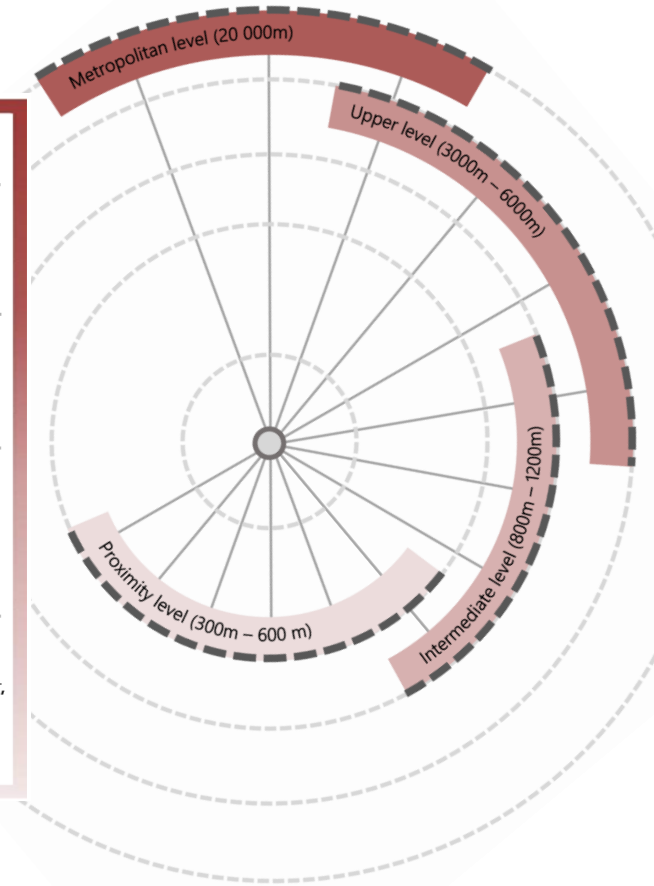


2. Needs and practices of the population

- Types of shops and services, frequency of use, Accessibility distance threshold
- land use planning standards an important role in classifying shops and services

- 1
- +
- 2
- +
- 3
- ▼
- 4

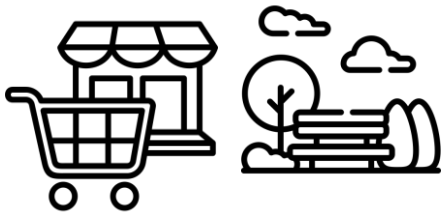
Levels		Rabat - Salé	Marne-la-Vallée
<p>Metropolitan level (Rare)</p>	Urban facilities that provide a structure for the town or conurbation, with a regional or national focus	<ul style="list-style-type: none"> - University - Regional hospital - Stadium - Major sports facilities 	<ul style="list-style-type: none"> - Theatre - Cinema - Souk, etc..
<p>Upper level (Monthly)</p>	Fewer and more specialised urban facilities than in the two lower levels, serving residents of several arrondissements/municipalities	<ul style="list-style-type: none"> - Secondary School (Lycée) - Local hospital - Municipal stadium - Large sports hall - Clothing shop, etc. 	<ul style="list-style-type: none"> - Health centre - Analysis laboratory - Cinema - Library - Clothing shop - Fish shop - DIY shop, etc.
<p>Intermediate level (Weekly)</p>	Shops and services less frequent but relatively numerous, serving populations on a larger scale	<ul style="list-style-type: none"> - Secondary School (Collège) - Health centre - Socio-cultural centre - Sports hall - Local market - Youth Centre - Dar Taliba 	<ul style="list-style-type: none"> - Police district - Friday Mosque - Bank - Supermarket - Bakery - Coffee shop, etc. - Secondary School - Bank - Restaurant - Supermarket - Post office - Frozen food shop - Butchers - Weekly market, etc.
<p>Proximity level (Daily)</p>	Regularly frequented shops and services, generally within the neighbourhood.	<ul style="list-style-type: none"> - Nursery - Elementary School - Police station - Four - Hammam - Local mosque 	<ul style="list-style-type: none"> - Local sports ground - Grocery store - Pharmacy, etc. - Bakery - Pharmacy - Nursery - Sports ground - Grocery store - Elementary school - Newsagent - General practitioner, etc.



Reference :

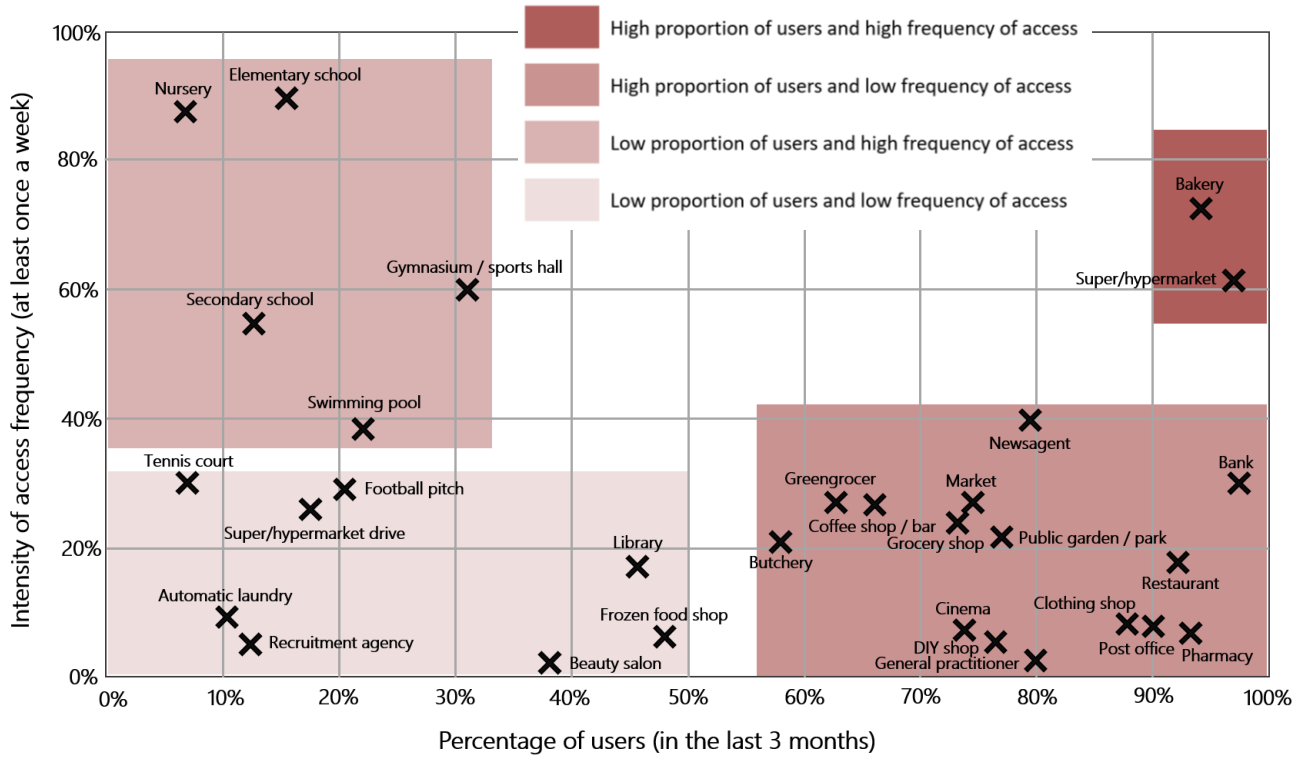
- AREA, 2016, Référentiel de programmation des équipements publics et privés d'intérêt général. Ministère de l'Urbanisme et de l'aménagement du Territoire, Direction de l'Urbanisme, Royaume du Maroc.
- Bonin O. et al., 2020, Projet SOFT : Sobriété énergétique par les formes urbaines et le transport. [Rapport de recherche] THÉMA, UMR 6049; Institut pour la Transition Energétique, Efficacity; LVMT.

- Reference :** Madec, P. et al., 2008, Le bio-îlot et la ville de la pantoufle. in Ecologik N° 5



2. Needs and practices of the population

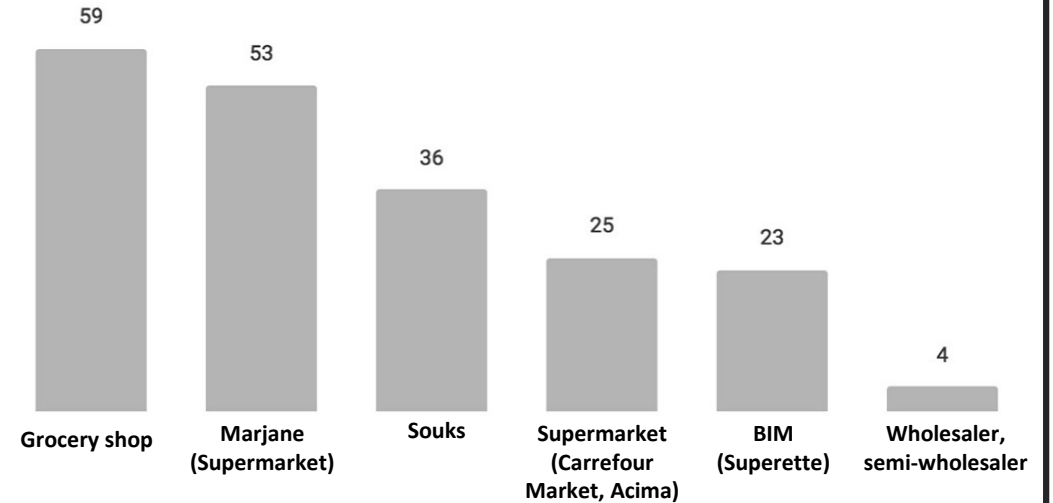
- Percentage of amenity users



Type of equipment, by number of users and frequency of use in Bordeaux (France)

Reference :

- A'urba, 2017. L'accès aux commerces et équipements de la vie quotidienne ; Résultats d'une enquête quantitative sur les usages et attentes des habitants dans l'aire métropolitaine de Bordeaux. Rapport d'étude.



Types of shops preferred by consumers in Rabat (% of respondents frequenting shops)

Reference :

- Es Saddouni, T. A., 2015, Analyse des lieux d'achat des ménagères d'El Jadida, Rapport de stage 5e année, HEC Rabat. From : Amine, A., Gallouj, C., 2021, Consommateurs et pratiques de consommation au Maroc. L'Harmattan.





3. Building the database

World open databases

- 1
- +
- 2
- +
- 3
- ▼
- 4

Marne-la-Vallée

BD Topo 2024 / OpenStreetMap 2024

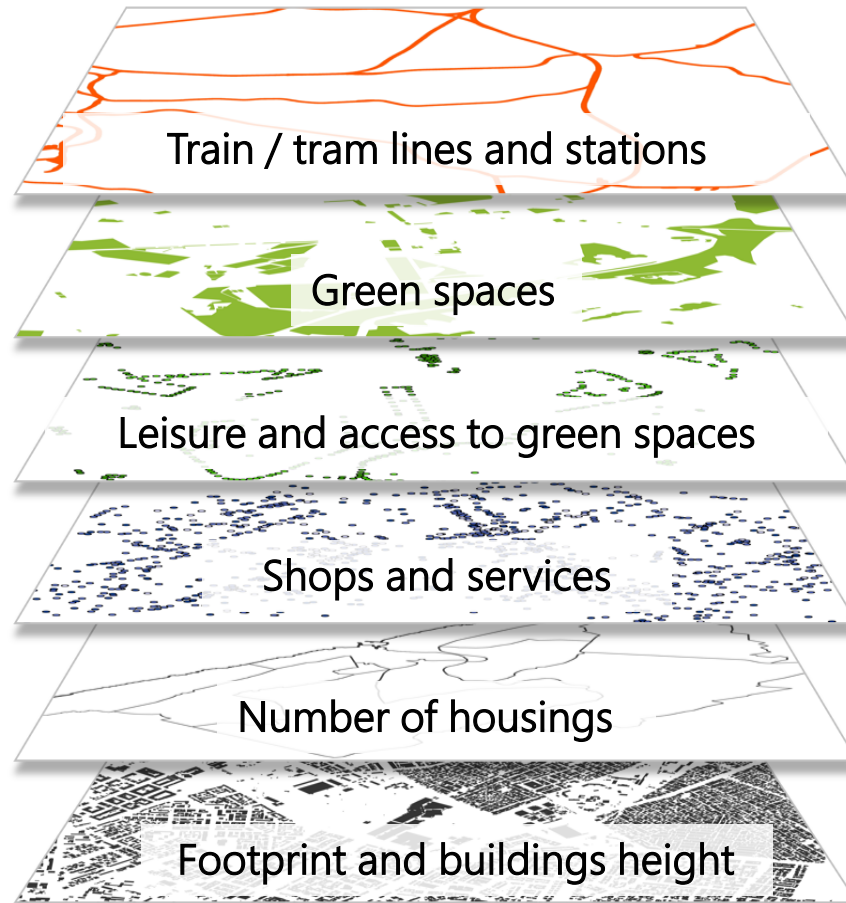
BD Topo 2024 / Datasets Institut Paris Région

BD Topo 2024 / Datasets Institut Paris Région

Base Sirene 2024 / Permanent Equipment Database INSEE 2021

INSEE - Recensement 2020 - Base infracommunale

BD Topo 2024 / National Buildings Database



Rabat - Salé

OpenStreetMap 2024

OpenStreetMap 2024

OpenStreetMap 2024

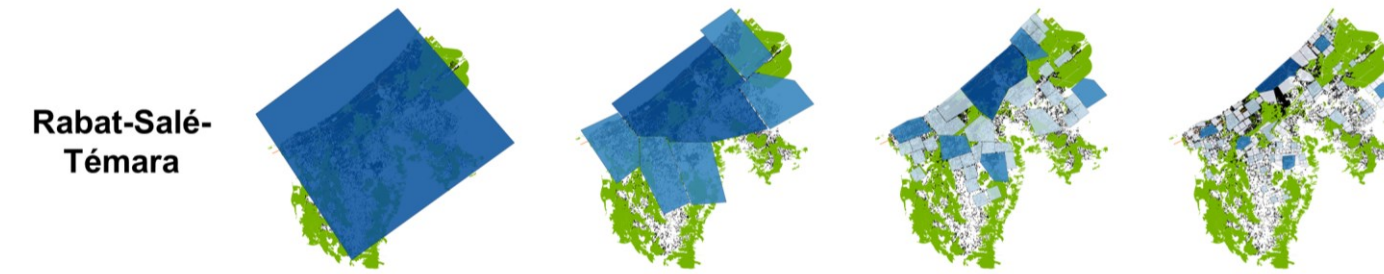
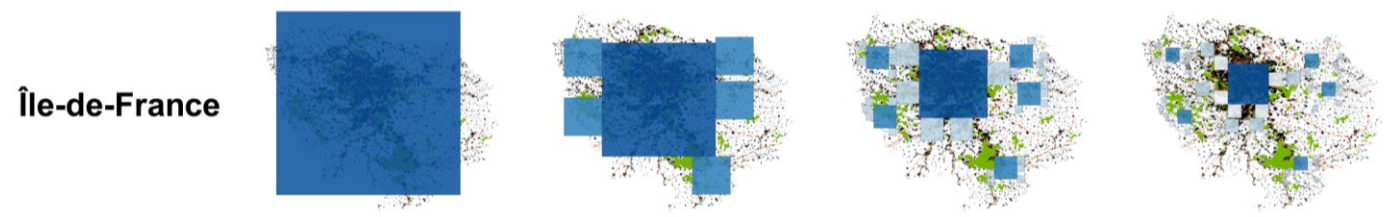
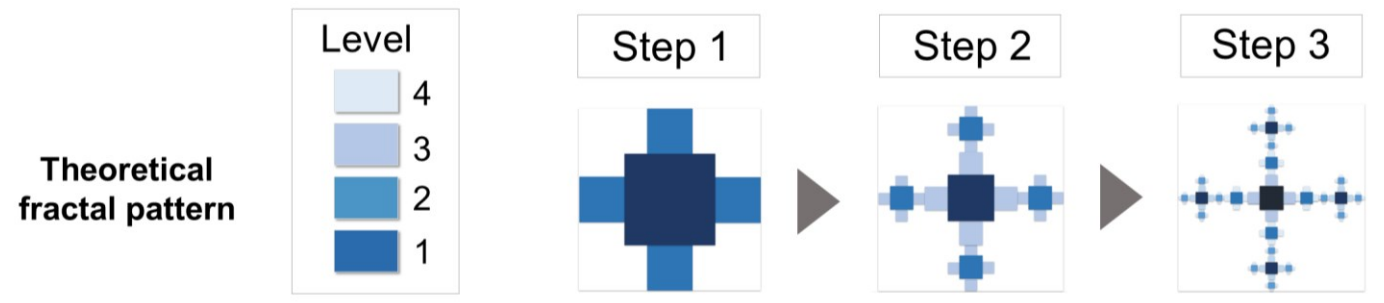
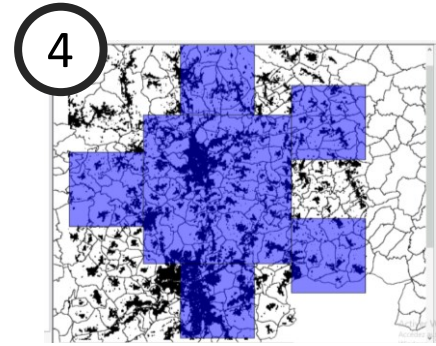
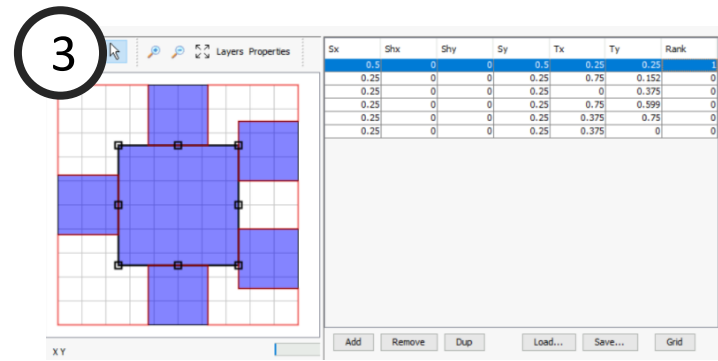
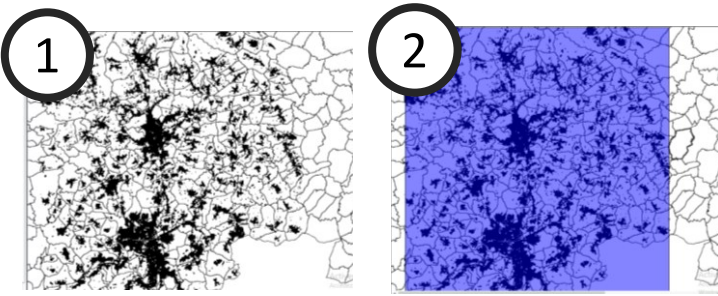
Google maps / Géoportail de l'AURS

Population census (RGPH) 2014 - by arrondissement

Google-Microsoft Open Buildings / GHS-BUILT-HR2023A

4. Delimiting study area, number and position of subcenters

- 1
- +
- 2
- +
- 3
- ▼
- 4

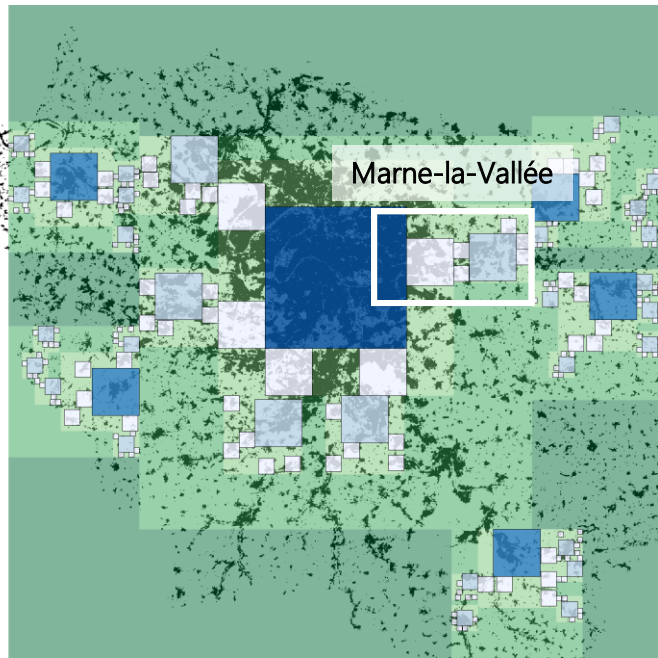


1 – Buildings and municipal boundaries / 2 – Delimitation of the study area / 3 - Iterative Function Systems (IFS) : the choice of number of subcenters / 4 – Positioning of centres in relation to buildings

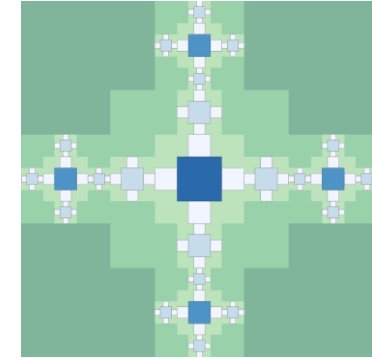
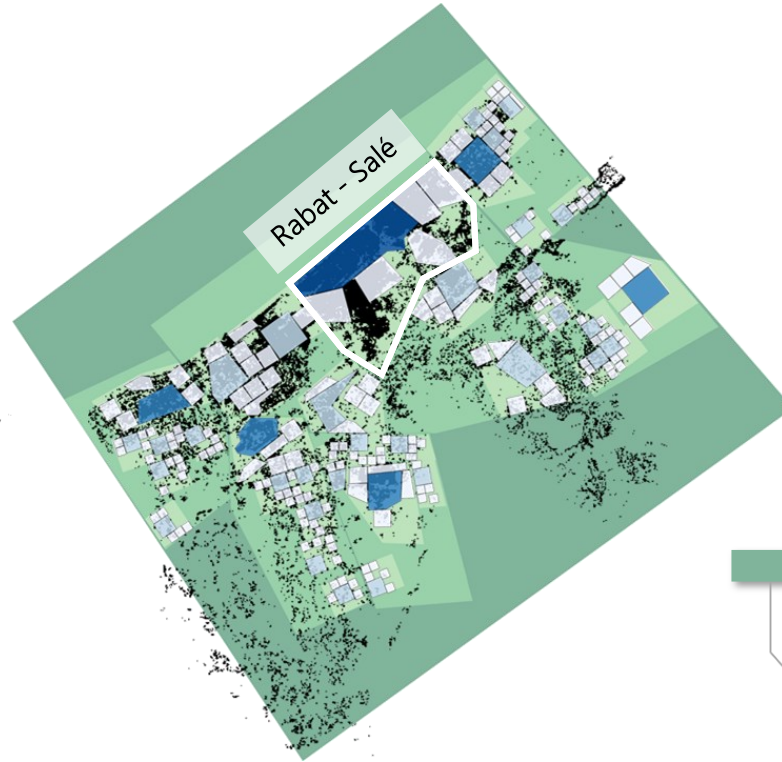
4. First step of analysis: the regional scale

- 1
- +
- 2
- +
- 3
- ▼
- 4

Ile-de-France Region



Rabat-Salé-Témara Conurbation

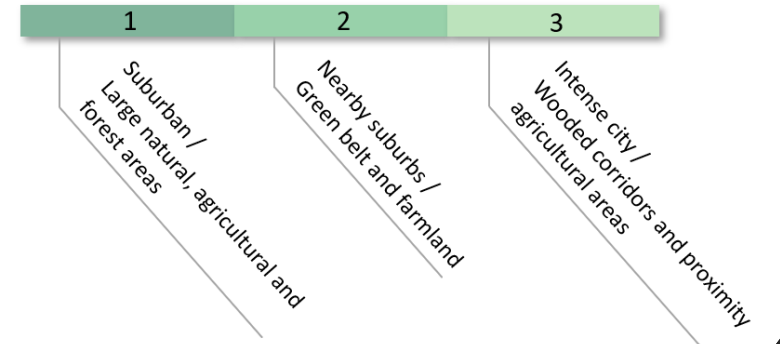


Theoretical pattern

Hierarchy of urban centres (degree of independence)

Step 0	1
Step 1	2
Step 2	3
Step 2	4

Urban thresholds and hierarchy of natural, agricultural and forest areas



4. Second step: The local scale - Fractalopolis Space System

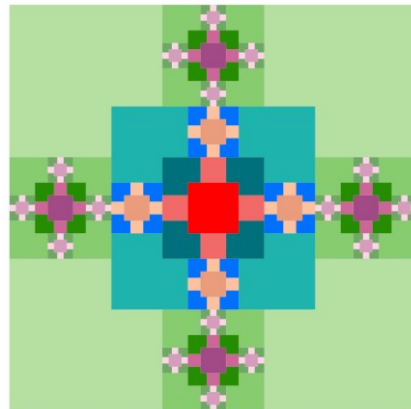
Marne-la-Vallée



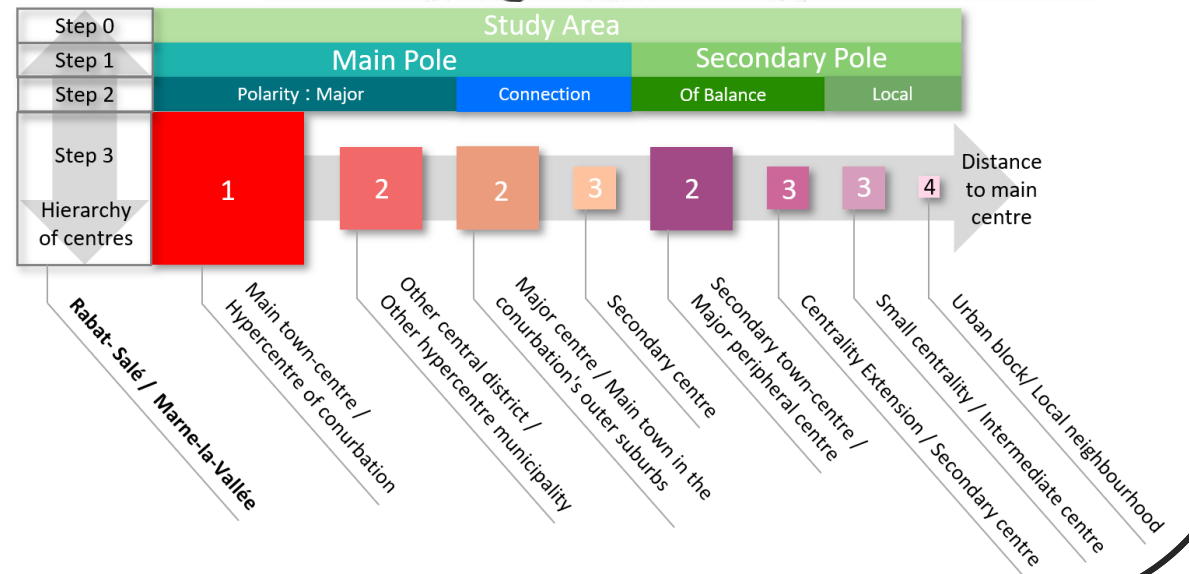
Rabat - Salé



- 1
- +
- 2
- +
- 3
- ▼
- 4



Theoretical pattern



4. Rules for calculating access performance for each centre

- 1
- +
- 2
- +
- 3
- ▼
- 4

The screenshot displays three main components of the GIS software interface:

- Parameters dialog:** A window titled "Parameters used to assess the interest of each square to be developed" with a table of rules. The "MACRO_Shop_F4" rule is highlighted in blue.
- Table:** A table with two columns: "Key" and "Value". It lists various keys and their corresponding values, which include percentages and coordinate pairs.
- Feature properties:** A panel on the right showing a list of properties for a specific feature, including macro shop and green scores.

Key	Value
520Z	15% - Points : {300.0=1.0, 600.0=0.0}
1071C	94% - Points : {300.0=1.0, 600.0=0.0}
8510Z	15% - Points : {300.0=1.0, 600.0=0.0}
4711B	74% - Points : {300.0=1.0, 600.0=0.0}
4762Z	80% - Points : {300.0=1.0, 600.0=0.0}
5310Z	90% - Points : {300.0=1.0, 600.0=0.0}

Property	Value
code	1101
level	4
size	3053.6620801100507
built_area	1227670.889374297
building_land_potential	1.0
housing_empirical	23247.2676867963
housing_density_empirical	24.930441189558096
housing_model	66080.69139799356
housing_density_model	70.86513618969072
diff_model-empirical	42833.42371119726
rate_model-empirical	184.24350703568433
shop1	0.5
shop2	1.0
shop3	1.0
shop4	1.0
leisure1	1.0
leisure2	0.75
leisure3	1.0
leisure4	0.5
morph	1.0
suitability	0.5839057765549227
MACRO_Shop_F1	0.9294619693781583
MACRO_Shop_F2	0.9915056190485418
MACRO_Shop_F3	0.856686517082668
MACRO_Shop_F4	0.5906492265772014
MACRO_Green_F1	0.5787986767289778
MACRO_Green_F2	0.15440730004839753
MACRO_Green_F3	0.307197391578031
MACRO_Green_F4	0.2625395119974068

- 1) Shops and services : frequency of use
- 2) Types of shops and services
- 3) Percentage of users by amenity (+ by frequency of use category)
- 4) Accessibility distance threshold
- 5) Results : Accessibility scores

4. shops and services : categories according to frequency of use

- For Marne-la-Vallée

4 Daily

Key	Value
BOULANGERIE	95% - Points : {300.0=1.0, 600.0=0.0}
PHARMACIE	93% - Points : {300.0=1.0, 600.0=0.0}
MÉDECIN GÉNÉRALISTE	88% - Points : {300.0=1.0, 600.0=0.0}
Maternelle	15% - Points : {300.0=1.0, 600.0=0.0}
SALLES MULTISPORTS (GYMNASES)	15% - Points : {300.0=1.0, 600.0=0.0}
ÉPICERIE	66% - Points : {300.0=1.0, 600.0=0.0}
LIBRAIRIE, PAPETERIE, JOURNAUX	80% - Points : {300.0=1.0, 600.0=0.0}
Primaire	56% - Points : {300.0=1.0, 600.0=0.0}
SUPÉRETTE	74% - Points : {300.0=1.0, 600.0=0.0}

2 Monthly

Key	Value
Maison_Sante	50% - Points : {3000.0=1.0, 6000.0=0.0}
GRANDE SURFACE DE BRICOLAGE	77% - Points : {3000.0=1.0, 6000.0=0.0}
POISSONNERIE	10% - Points : {3000.0=1.0, 6000.0=0.0}
Specialiste	46% - Points : {3000.0=1.0, 6000.0=0.0}
LABORATOIRE D ANALYSES ET DE BIOLOGIE ...	50% - Points : {3000.0=1.0, 6000.0=0.0}
CINÉMA	63% - Points : {3000.0=1.0, 6000.0=0.0}
BIBLIOTHÈQUE	27% - Points : {3000.0=1.0, 6000.0=0.0}
MAGASIN DE VÊTEMENTS	88% - Points : {3000.0=1.0, 6000.0=0.0}
ATHLÉTISME	90% - Points : {3000.0=1.0, 6000.0=0.0}
SALLES DE REMISE EN FORME	10% - Points : {3000.0=1.0, 6000.0=0.0}

3 weekly

Key	Value
FLEURISTE-JARDINERIE-ANIMALERIE	33% - Points : {800.0=1.0, 1600.0=0.0}
BASSIN DE NATATION	24% - Points : {800.0=1.0, 1600.0=0.0}
Lycée	40% - Points : {800.0=1.0, 1600.0=0.0}
PRODUITS SURGELÉS	40% - Points : {800.0=1.0, 1600.0=0.0}
BANQUE, CAISSE D'ÉPARGNE	97% - Points : {800.0=1.0, 1600.0=0.0}
DROGUERIE QUINCAILLERIE BRICOLAGE	77% - Points : {800.0=1.0, 1600.0=0.0}
RESTAURANT - RESTAURATION RAPIDE	90% - Points : {800.0=1.0, 1600.0=0.0}
SUPERMARCHÉ	97% - Points : {800.0=1.0, 1600.0=0.0}
BOUCHERIE CHARCUTERIE	56% - Points : {800.0=1.0, 1600.0=0.0}
COLLÈGE	40% - Points : {800.0=1.0, 1600.0=0.0}
HYPERMARCHÉ	97% - Points : {800.0=1.0, 1600.0=0.0}
Poste	90% - Points : {800.0=1.0, 1600.0=0.0}

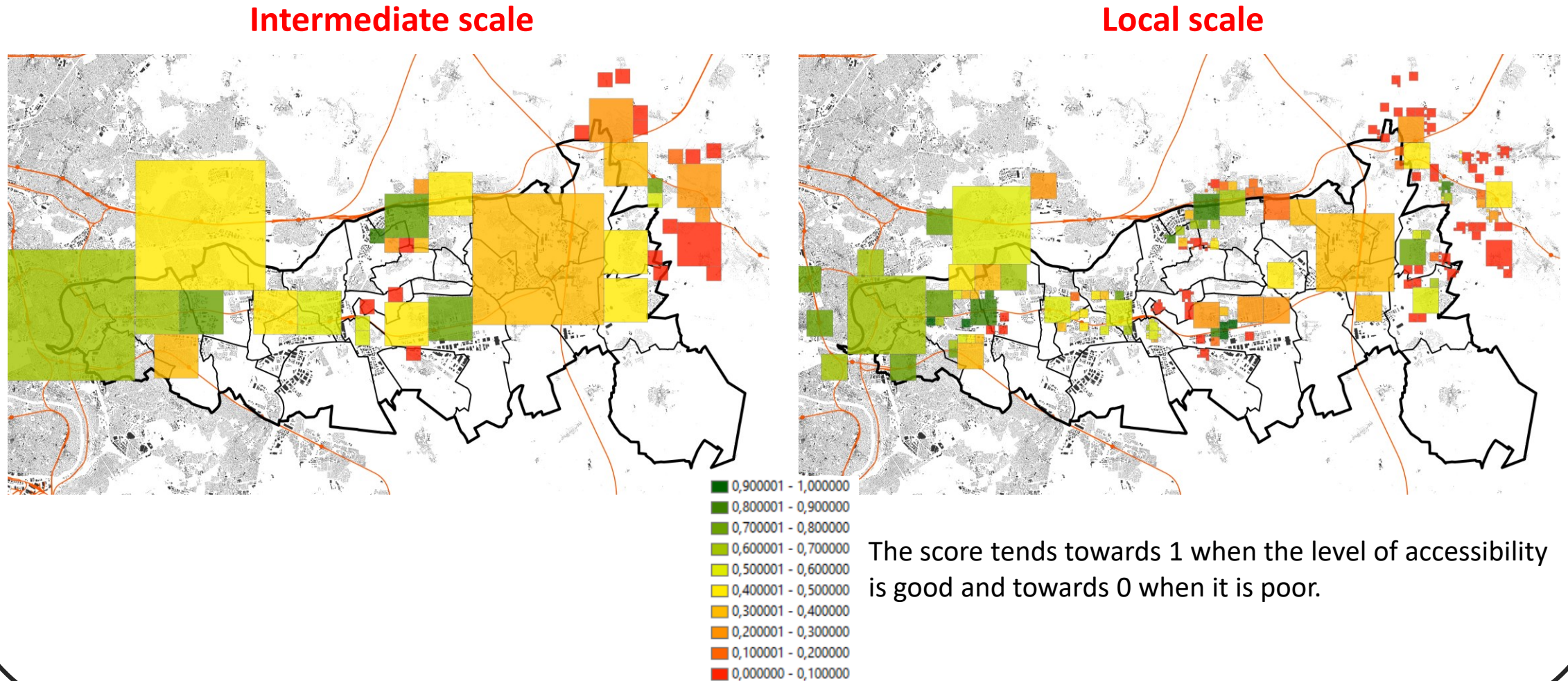
1 Rare

Key	Value
Musée	30% - Points : {0.0=1.0, 20000.0=0.0}
HORLOGERIE-BIJOUTERIE	70% - Points : {0.0=1.0, 20000.0=0.0}
Université	15% - Points : {0.0=1.0, 20000.0=0.0}
Hopital	50% - Points : {0.0=1.0, 20000.0=0.0}
ARTS DU SPECTACLE	10% - Points : {0.0=1.0, 20000.0=0.0}
CONSERVATOIRE	10% - Points : {0.0=1.0, 20000.0=0.0}



4/ Results of accessibility measurements

- Accessibility scores for shops and services, by level of spatial scale (Marne-la-Vallée)



- 1
- +
- 2
- +
- 3
- ▼
- 4

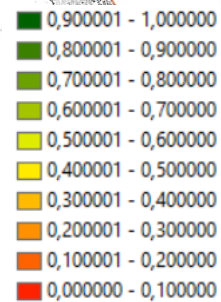
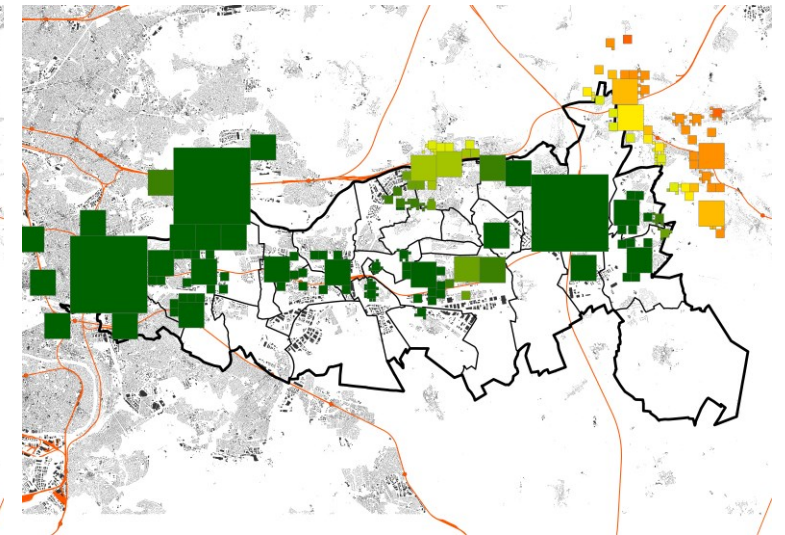
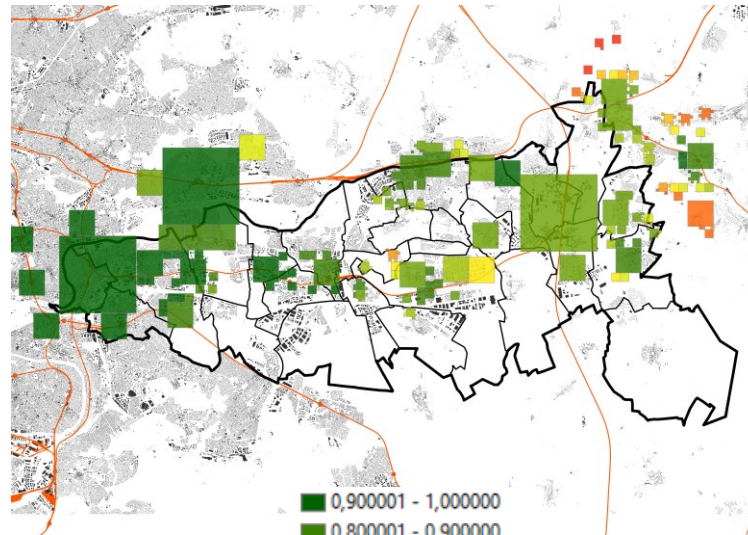
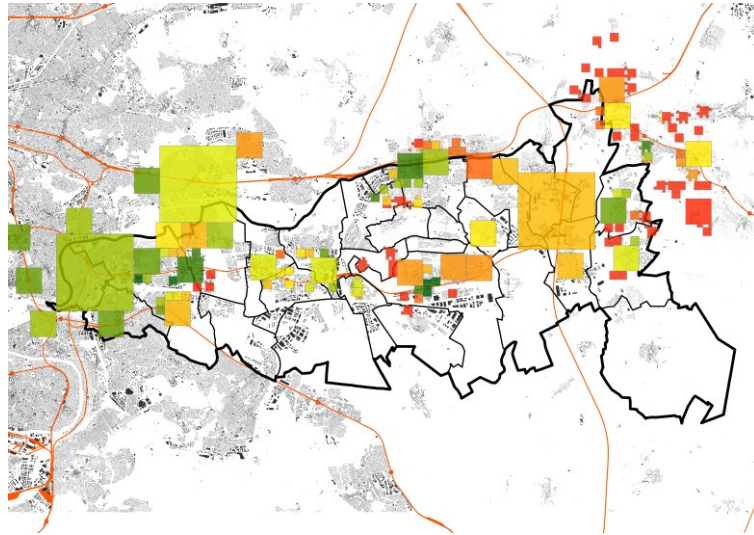
4/ Results of accessibility measurements

- Accessibility scores for shops and services, by frequency of use category (Marne-la-Vallée)

④ Daily

③ weekly

② Monthly



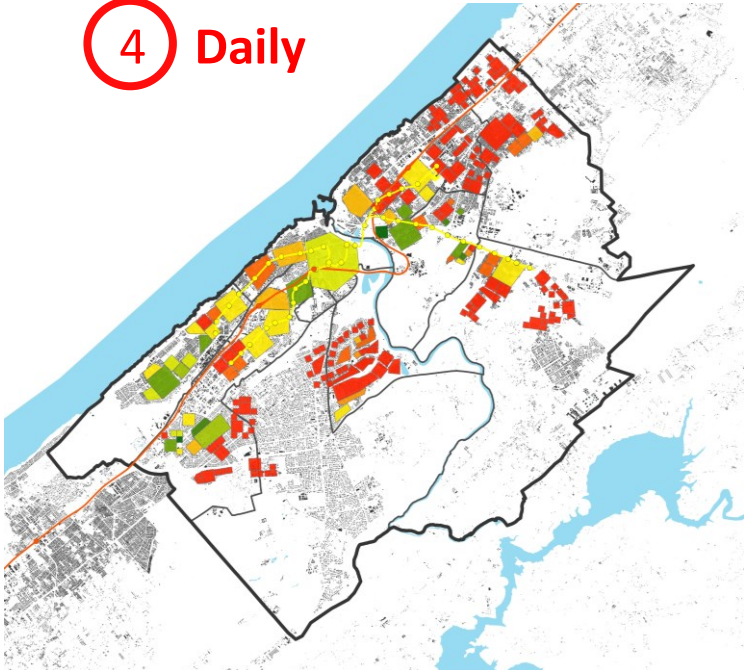
- 1
- +
- 2
- +
- 3
- ▼
- 4

4/ Results of accessibility measurements

- Accessibility scores for green spaces and leisures, by frequency of use category (Rabat-Salé)

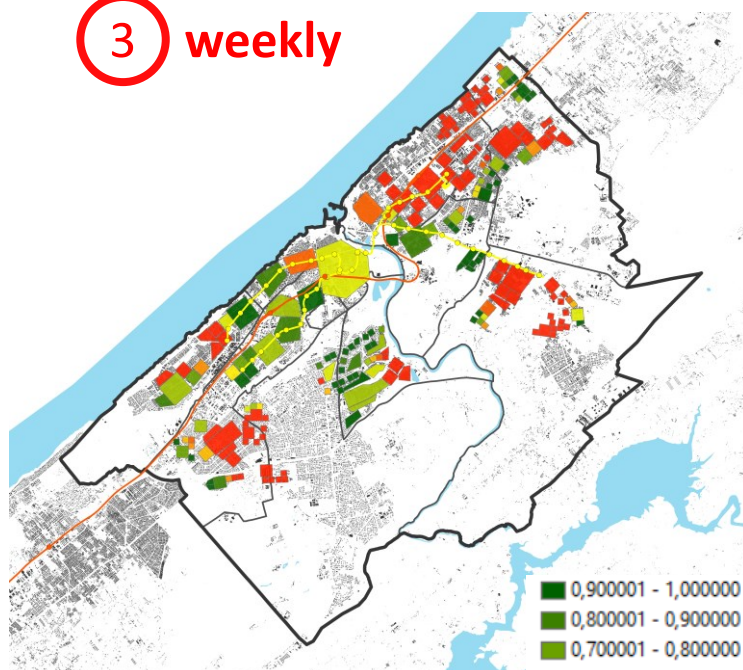
- 1
- +
- 2
- +
- 3
- ▼
- 4

4 Daily



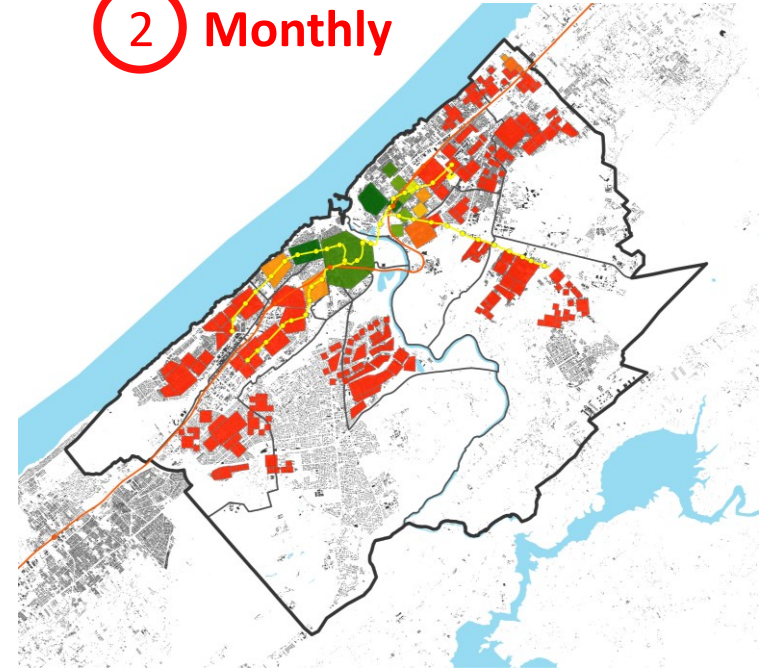
Types : Recreation ground / Playground / Park

3 weekly

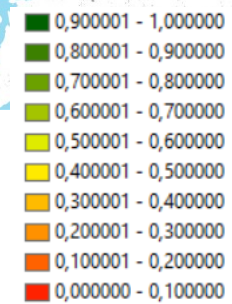


Type : Forest

2 Monthly



Type : Beach



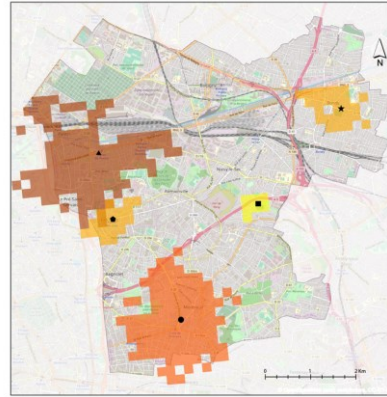
Conclusion and next step

Future scenarios



- Forecasts on the future development of the study areas (with UrbanSimul tool)

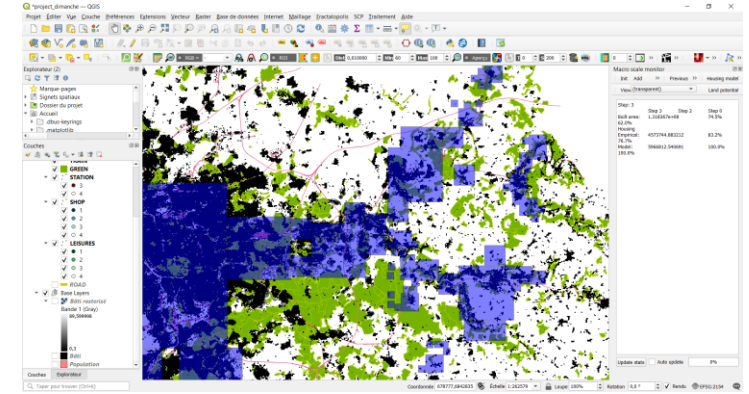
New indicators



- Boulangerie
- Supérette
- Bijouterie
- Hypermarché
- ▲ Magasin de bricolage

- Opening times for shops and services
- Assessing the profitability of amenities

« Fractalopolis: from Java to QGIS » :



C. Regrain, P. Frankhauser, ThéMA, 2022

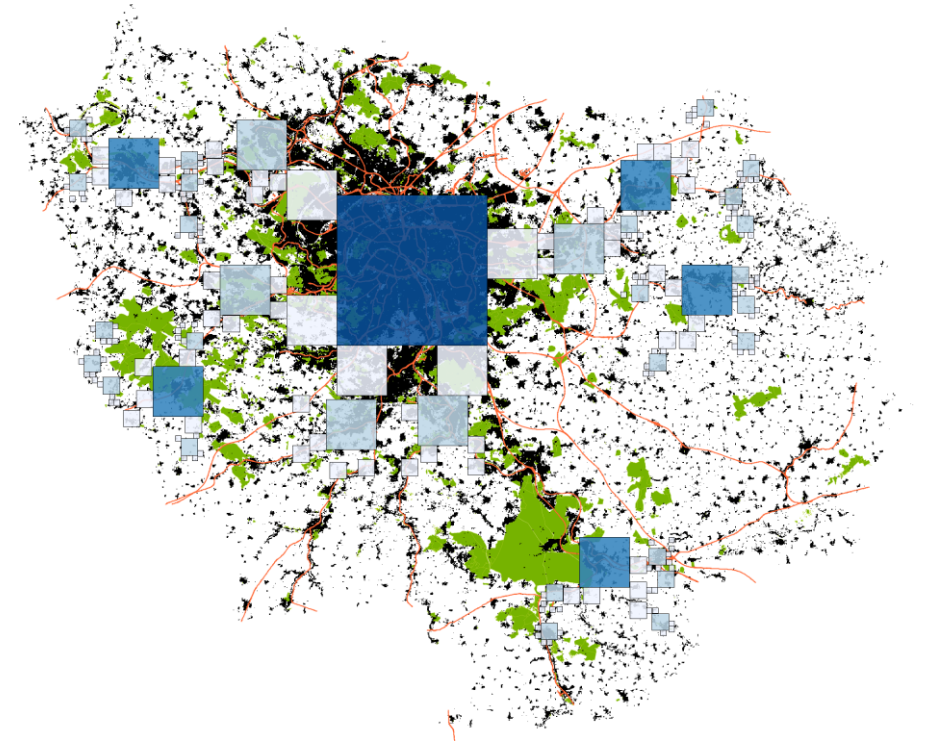
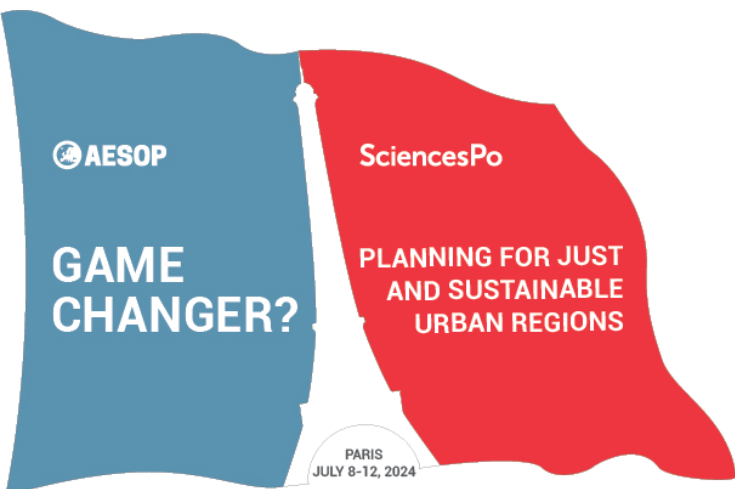
- A QGIS plugin version is currently being programmed

Presentation and collaboration with urban planners



References

- Aupa. (s. d.), 2022, La ville des courtes distances : du concept à la réalité <https://aupa.fr/la-ville-des-courtes-distances-du-concept-a-la-realite/>
- Bonin O., Bonneau P., Clerc M., Cousin J., Frankhauser P., et al., 2020, Projet SOFT : Sobriété énergétique par les formes urbaines et le transport. [Rapport de recherche] ThéMA, UMR 6049; Institut pour la Transition Énergétique, Efficacity; LVMT, 214 p. (hal-03111221) <https://hal.science/hal-03111221>
- Büttner, B., Seisenberger, S., Baquero Larriva, M., Gante, A., Ramírez, A., & Haxhija, S., 2022, Urban Mobility Next 9 ±15-Minute City : Human-centred planning in action Mobility for more liveable urban spaces EIT Urban Mobility Munich November 2022. <https://doi.org/10.13140/RG.2.2.10482.79041>
- Frankhauser, P., 2023, A Multiscale Planning Concept for Sustainable Metropolitan Development. ICCSA 2023, National Technical University of Athens and University of the Aegean, Athens, Greece
- Frankhauser, P., 2021, Fractalopolis : a fractal concept for the sustainable development of metropolitan areas. Complex Systems, Smart Territories and Mobility, Springer International Publishing, pp.15-50. https://link.springer.com/chapter/10.1007/978-3-030-59302-5_2
- Gaglione, F., Gargiulo, C., & Zucaro, F., 2023, Urban accessibility planning: comparing 3 cases studies through the 15-minute city approach. Accessibility and Connectivity of the 15-minute-city, Milano. Zenodo. <https://doi.org/10.5281/zenodo.7752398>
- Institut Paris Région, 2023, Île-de-France 2040, un nouvel équilibre : projet d'aménagement régional. Schéma directeur de la région Île-de-France environnemental, Projet arrêté par le Conseil régional le 12 juillet 2023, Région Île-de-France. <https://www.iledefrance.fr/participer-la-vie-citoyenne/je-participe-la-vie-de-la-region/le-sdrif-e-ile-de-france-objectif-2040>
- Institut Paris Région, 2011, Les démarches inter-Scot en France, <https://www.institutparisregion.fr/nos-travaux/publications/les-demarches-inter-scot-en-france/>
- Lanza, G., Pucci, P., & Carboni, L., 2023, From mobility to accessibility by proximity: an Inclusive Accessibility by Proximity Index (IAPI). Accessibility and Connectivity of the 15-minute-city, Milano. Zenodo. <https://doi.org/10.5281/zenodo.7752421>
- PMUD Rabat-Salé-Skhirat Témara, Compte Instagram (2024) https://instagram.com/pmud_rabat_sale_skhirat_temara?igshid=ZDdkNTZiNTM=
- Steuteville, R., 2023, Hierarchy of centers for the 15-minute city – City of Portland www.cnu.org
- Yamu C., Frankhauser P., 2015, Spatial accessibility to amenities, natural areas and urban green spaces: using a multiscale, multifractal simulation model for managing urban sprawl, *Environment and Planning B: Planning and Design*, 42(6), 1054-1078. <https://research.rug.nl/en/publications/spatial-accessibility-to-amenities-natural-areas-and-urban-green->
- 6t-bureau de recherche, 2022, Territoire des courtes distances : Diagnostic et enjeux pour le Canton de Genève et le Grand Genève. (s. d.). <https://www.6-t.co/article/territoire-des-courtes-distances-diagnostic-et-enjeux-pour-le-canton-de-geneve-et-le-grand-geneve>



Xavier Lehmann : xavier.lehmann@enpc.fr

Pierre Frankhauser : pierre.frankhauser@wanadoo.fr

Olivier Bonin : olivier.bonin@univ-eiffel.fr