

TIMES and prospective modelling for urban planning

Study on the evaluation of urban transformation scenarios that respond to both energy, climate and socio-cultural issues.

Matthieu Denoux^{1,2}

¹The Centre for Applied Mathematics
MINES ParisTech - PSL Research University
matthieu.denoux@mines-paristech.fr

²ANMA (Agency Nicolas Michelin and Associates)

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- increasingly concentrating *population*;
- responsible for a large part of *GHG emissions* and *energy consumption*;
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French **urban planners** and stakeholders are not well equipped to face **long-term** issues:

- no *scientific* background (no idea of what is possible);
- no *money* for studies or scenarios;
- already *strong challenges*;
- *but* a high interest on *strategic* advices.

- 1 State of the art
 - Existing reviews
 - Topics
- 2 TIMES and urban modelling
 - Prospective modelling approach applied to cities
 - Issues already identified
 - TIMES city modelling
- 3 Conclusion and perspectives

Section 1

State of the art

Already a lot of works:

- because of the key role played by cities in climate change issues [OECD, 2010; UN, 2016; UN, 2017];
- because cities are gathering many people who want a certain quality of life;
- because of national or european funds (FP7¹, ANR²);
- because of private interests (property developers, energy companies, software developers...);

¹European program.

²ANR: French national agency for research.

Source	Desc	Scale
Keirstead et al., 2012	comprehensive review on Urban Energy Systems	<i>Variable</i>
Grimmond et al., 2010; Grimmond et al., 2011	on surface energy balance	Building
Alhamwi et al., 2017	tools (GIS) oriented and review	City
Shi et al., 2017	replace buildings shapes creation by computer-assisted tools	Building
Allegrini et al., 2015	-	District
Mendes et al., 2011	ICES (Integrated Community Energy Systems)	<i>Variable</i>
C. Kennedy et al., 2011	metabolism approaches	City
Geneletti et al., 2017	sustainable approach in periurban fringes	Peri-urban
Swan et al., 2009	energy consumption in residential	<i>Sector</i>
Engel-Yan et al., 2005	infrastructures and quality of life	District
Connolly et al., 2010	integration of renewable energy	<i>Variable</i>
Vreenegoor et al., 2004	energy performance	District

- Cities operations, investment decision, location choice, e.g. Artelys software;
- Climate modelling, e.g. for renewable energy sources potential [Amado et al., 2012];
- Urban Heat Island mitigation, e.g. [Masson et al., 2014; Salvati et al., 2017];
- Pollution simulation, e.g. cf. CEREIA (ENPC) work;
- Urban metabolism and flux, e.g. [Barles, 2015; Christopher Kennedy, 2012];
- Building and building energy consumptions optimisation, e.g. [Swan et al., 2009; Nouvel et al., 2017];
- Transport and mobility, e.g. [Arampatzis et al., 2004];
- Urban growth, e.g. [Angel et al., 2007];
- Representation of existing buildings in a city [Gadsden et al., 2003; Mutani et al., 2016; Kellett et al., 2013; Tornay et al., 2017];
- Inhabitants behaviors, e.g. [Le Gallic et al., 2016; Schwartz, 2006];
- Decision support, e.g. [Haurie, 2001; Fragniere et al., 1999; Assoumou et al., 2015].

Also **legal** or **institutions** inputs in France:

- Energy issues barely taken into account in planning legal documents;
- Climate change mitigation acknowledged but not prioritized of high importance;
- Fauna and flora more watched (obligation to preserve, compensate, etc.);
- Advices from government, national or regional agencies (e.g. ADEME) to include climate change issues into urban and regional planning documents.

Urban planners:

- Contextual approaches;
- Attracting elements in the territory;
- Respect of existing buildings.

Projects

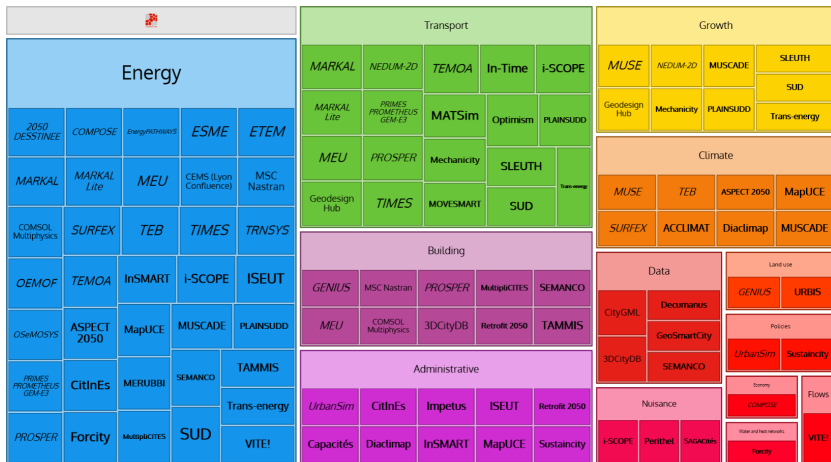


Figure: Set of similar projects or models

On research:

- No study from urban planning point of view;
- Not many studies on long-term (e.g. Masson et al., 2014);
- Often on a too detailed scale (building) or too large (aggregate at city level) for urban planners;

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From research:

- Data availability at studied level is a key issue;
- Cities are highly dependent of their environment and close regions;

Section 2

TIMES and urban modelling

Current approaches from urban planners met in France:

- *Intuitive*, experience-based;
- Respect of the *territory logics*;
- *Ideas* on ecology, energy and social;
- Slowly using *data science* potential (through technical consultants).

Current approaches from urban planners met in France:

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Need from urban planners:

- Data increasingly available;
- Insert sciences in the process of urban creation;
Careful: not replace urban planners but provide **decision support**;
- Evaluate if their ideas do respect their intentions;
- "*Think before drawing*";
- Give insight of **long-term** data concerning scenarios of development;
- Apply prospective modelling to town planning.

Issues already identified

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- Often not available at wanted scale;
- Confidentiality issue (local authorities not willing to give away their data);
- Coherence, ambiguity, reliability.

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 - blurs the interpretation;
 - diminishes the effects of urban transformations;
 - makes it impossible to find relevant and precise data.

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- Too general (only cities? whole metropolitan?):
 - how to take into account local changes;
 - how to respect the geography and existing artificial elements;
 - needs another model between both scales;
 - not relevant.

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How to represent non energetic, social, aesthetic issues?

How?

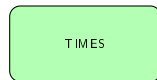
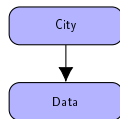
- Choose a city;

City

TIMES

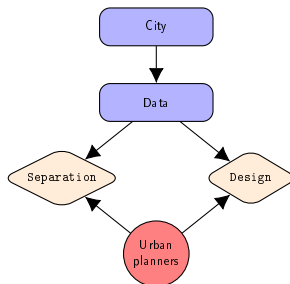
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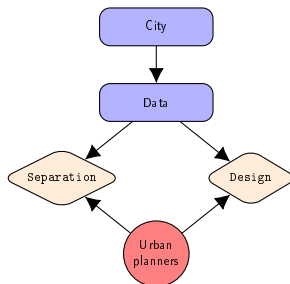
How?

- Choose a city;
- Define the **smallest scale** depending on available data (IRIS for France);
- Create technologies for each different "way of living in cities", for each **archetype** [Christen et al., 2012; Kellett et al., 2018; Gadsden et al., 2003; Mutani et al., 2016]:
 - From data;
 - From urban planners experience;
 - From imagined scenarios.



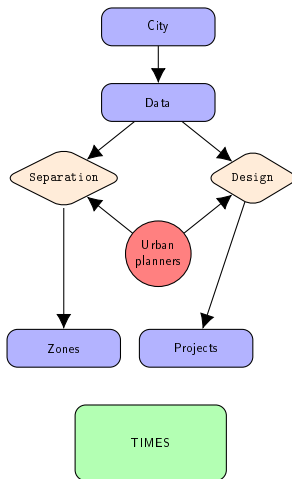
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- Associate *each small element* (IRIS) with *archetypes*;



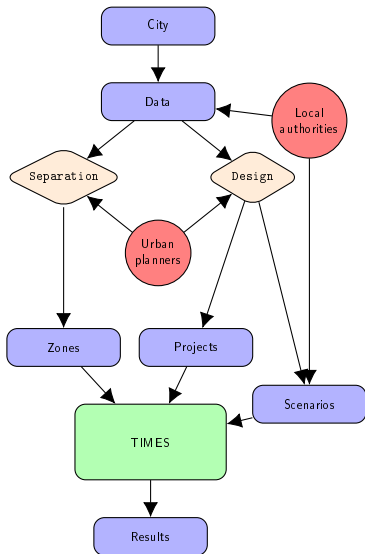
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- Associate *each small element* (IRIS) with *archetypes*;
- Separate the city territory in **zones**:
 - Following districts or cities boundaries;
 - Because of urban logic;
 - Similar from a data perspective;



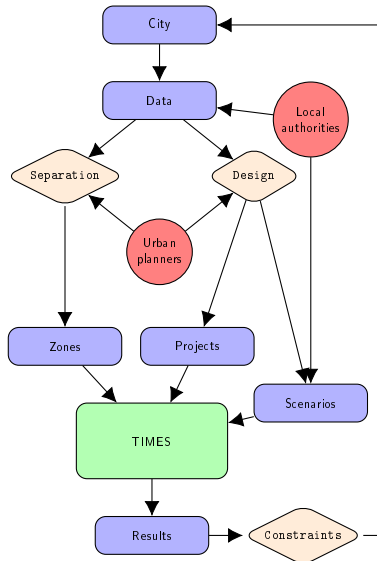
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- Add constraints, scenarios (TIMES);



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 - Similar from a data perspective;
- Add constraints, scenarios (TIMES);
- Apply solutions to the territory [Nouvel et al., 2015].



Results on Bordeaux (France)

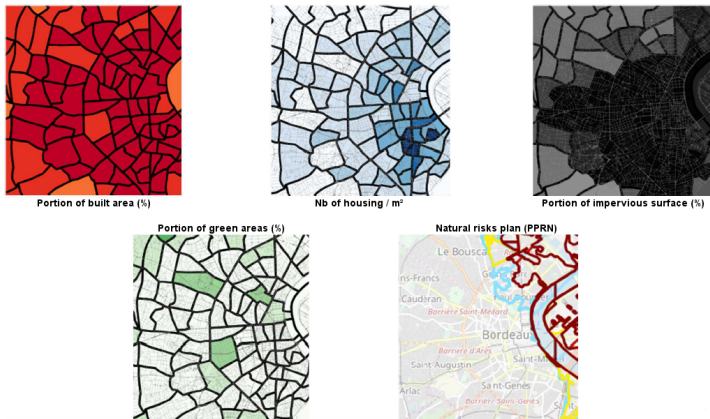


Figure: Examples of data for Bordeaux metropolitan territory

Pluridisciplinary by Gonçalves et al., 2017; *Urban ecosystems* by Larondelle et al., 2013; *Sociology, migration and agriculture* by Iaquina et al., 2000; *Statistics* by Danielaini et al., 2017; *Land-use and satellites pictures analysis* by Huang et al., 2016.

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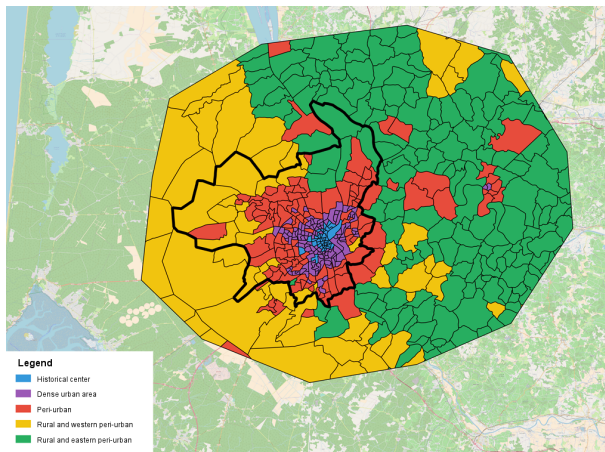
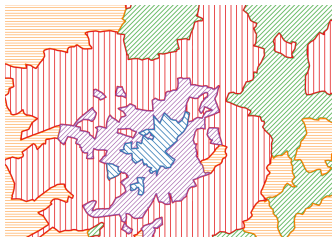
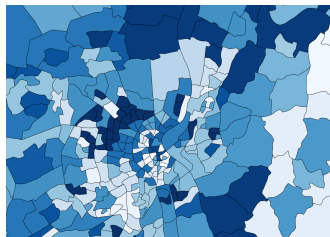


Figure: Examples of result for Bordeaux metropolitan territory



and



give



Figure: Zones (5) and archetypes (30) fusion: each zone has X times each archetype.

Section 3

Conclusion and perspectives

Real need from *urban planners* for scientific validation and means of comparison.
Real need for *energy* issues for long-term modelling.

First step done:

- Choice of a specific city (Bordeaux in France);
- Data collection;
- Representation and clustering of small areas of the city.

Next steps:

- More data needed (unavailable online);
- TIMES modelling.

Thanks

Thank you for your attention!

Open to *any suggestion!*

matthieu.denoux@mines-paristech.fr

PhD, Center for Applied Mathematics (**MINES ParisTech**)

Supervised by *Nadia Maïzi*

Collaboration with **Agence Nicolas Michelin & Associés** (french architecture and urban planning agency located in Paris):

- That instigated the project;
- To think of a way to help urban planners and not replace them;
- To discover how this unknown domain works;
- To have applications opportunities;
- To have information from the inside of town planning companies.

Supervised by *Mélusine Hucault*

Data used (uptil now) I

Source	Name	Description	Units
BDX	<i>woods</i>	Forest surface	%
	<i>group #*</i>	21 groups according to activities zones of local land-use plan	/
	<i>flood zone**</i>	groups according to flood risk prevention plan	/
	<i>forest fires**</i>	groups according to natural risk prevention plan	/
	<i>flu trans***</i>	motorized flows between zones [CUB et al., 2009]	/
Urban atlas (Copernicus)	<i>green spaces</i>	Green spaces area	%
	<i>entropy</i>	Huang et al., 2016	/
CLC (Copernicus)	<i>clc entropy</i>	Huang et al., 2016	/
	<i>cop moy emissi</i>	Larondelle et al., 2013	/
	<i>cop moy fvalue</i>	f-evapotranspiration, Larondelle et al., 2013	/
	<i>cop moy imperv</i>	Larondelle et al., 2013	/
	<i>cop moy trees</i>	Larondelle et al., 2013	/
	<i>cop build area</i>	Built land area	%
	<i>enedis cons resid</i>	Residential sector electricity consumption	MWh
Enedis	<i>enedis cons terti</i>	Services sector electricity consumption	MWh
	<i>enedis pv elc prod</i>	PV electricity production	MWh

Data used (uptil now) II

Source	Name	Description	Units
IGN	<i>ign built area</i>	Built land area	%
	<i>road length perc****</i>	Road length	m/m ²
	<i>road area perc****</i>	Road area	m ² /m ²
INSEE	<i>pop density</i>	Population density	inhab/m ²
	<i>duration moving</i>	Average duration since move-in	year
	<i>housing aver area</i>	Average area of housing	m ²
	<i>nb flats</i>	Number of flats	/
	<i>nb housing</i>	Number of housing	/
	<i>nb houses</i>	Number of houses	/
	<i>private vehicles</i>	Average private vehicles per capita	/
SIREN	<i>siren companies</i>	Number of declared companies (SIREN)	/
/	<i>distance center</i>	Distance to metropolitan center (Bordeaux historical center)	m

* only recommendations from local authority.

** not usable like that (very specific to some IRIS).

*** data from CUB et al., 2009.

**** separates IRIS between high density, around the center and the others, with a low density, mostly in periphery.



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