Economic consequences of Floods: modelling impacts in urban areas

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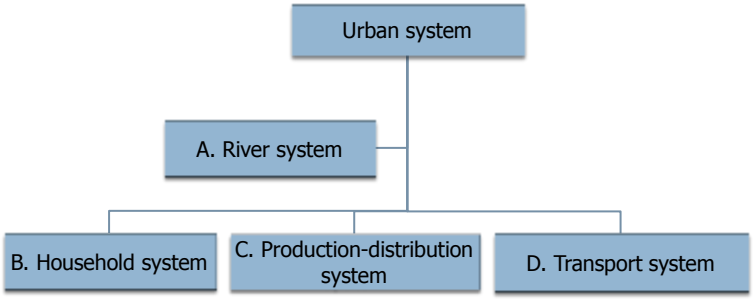
METHODOLOGY

- The model focuses on the households and their economic relations within the city (consumption, work).
- Floods will affect these relations.

METHODOLOGY



METHODOLOGY

- The city is represented by 4 integrated systems:
  1. **river system:** flood modelling (return period, depth, velocity and duration)
  2. **household system:** agent based model and network analysis (socio-economic characteristics of residents, their consumption practices and household assets)
  3. **production-distribution system:** agent based model and network analysis (characteristics of firms and the labor demand)
  4. **transport system:** simulation models (time and distance of displacement).

METHODOLOGY

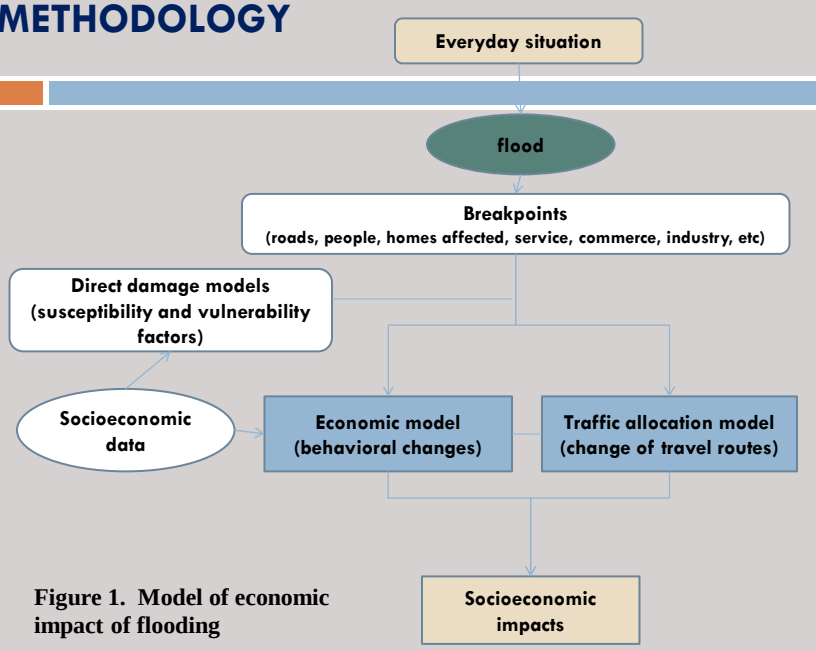


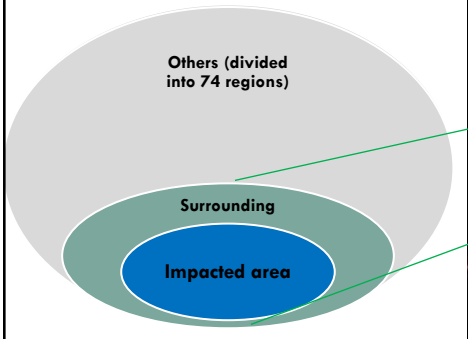
Figure 1. Model of economic impact of flooding

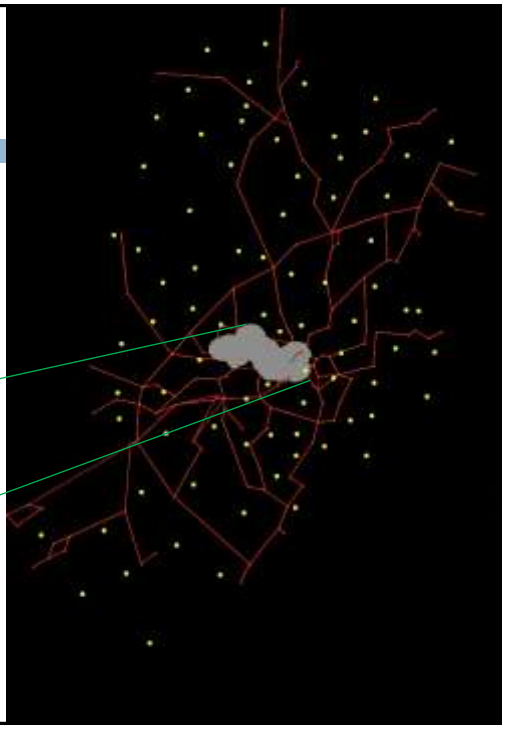
METHODOLOGY

- A prototype was created to simulate the economic relations between families and firms.
- It is a hybrid model: virtual city + real socio-economic information's census (Belo Horizonte)
- Aggregating the information of all agents of each system, the model should be able to show the behavior of municipal income, the stock of household assets and the value added to the economy.

THE PROTOTYPE

(model: Netlogo)





THE PROTOTYPE

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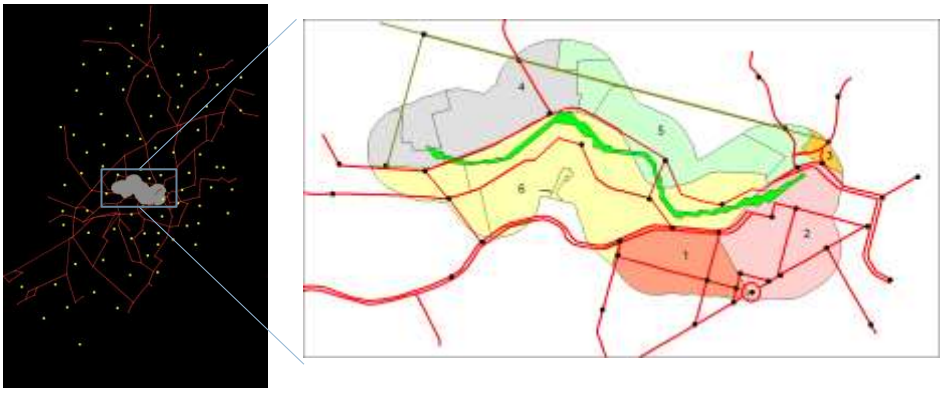


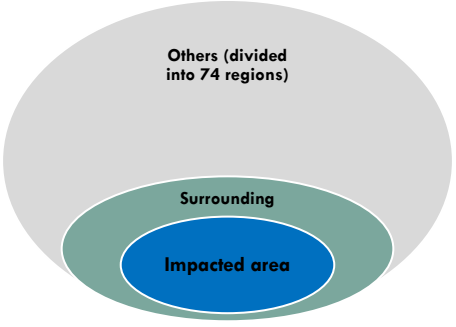
THE PROTOTYPE

Region of direct impact and surroundings:

- 14,315 households (20.530 workers);
- 5,050 firms.
- average income: 1,200 Euro/month

Others regions of the city:

- 74 regions: clusters of firms and
  - 164,379 households;
  - 19,084 firms.
  - average income: 1,300 Euro/month



Equilibrium of the model :

Labors supply = Labor demand Salaries = income = expenditure

METHODOLOGY: spatial distribution of households and fims

- Households distributed according to census data for Belo Horizonte.
- Firms distributed according to different data bases and 11 criteria:
  - Commerce, services and industries: Municipal data base (GIS)
  - Hospitals and schools (up to high school): GIS
  - Universities, museums, libraries: phone directory

METHODOLOGY

Socioeconomic data: household matrix

- 12 types of families
- 82 variables:
  - Dwelling characteristics (e.g.: location, dwelling area, build characteristics, water services provision)
  - Family income
  - Types of expenditures (59 types)
  - Dwelling contents (TV, cars, furniture, etc.)
- Census data (IBGE, 2000, 2003)

METHODOLOGY

Socioeconomic data: family members matrix

- 58 variables
  - Physical characteristics (e.g.: age, gender, health conditions, mobility);
  - Functions in the household (e.g.: occupation code, work hours, etc.);
  - Education;
  - Income;
- Census data

METHODOLOGY

Socioeconomic data: firm matrix

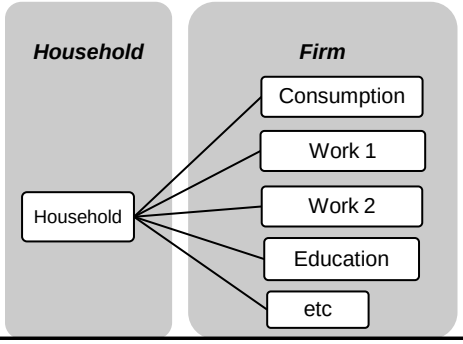
- 88 types of activities:
  - Types of offer:
    - 3 types of spatial distribution (e.g.: bakery, hospital)
    - 3 types of good characteristics: essential, necessary, luxurious
    - Frequency of consumption: daily, weekly, monthly, rare
  - Number of employees;
- Census data, business data

METHODOLOGY

Relationship between agents (matrixes)

Work and study allocations:

- Random selection of the firm by workers working in the firm field – limit: number of employees per firm
- Closest fundamental school, plus random selection of school for higher level – other criteria: domain of studies, school capacity

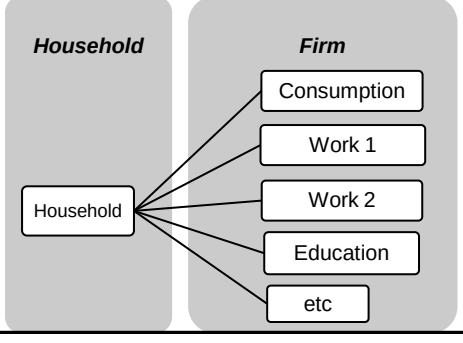


METHODOLOGY

Relationship between agents (matrixes)

Expenditure allocation decision:

- The agent choose the firm according to those that are able to furnish the good X (1-59 options)
- Distance accepted by the agent to travel in order to buy the good X (depends on good characteristics and on spatial distribution of firms).



METHODOLOGY

The river system

- Rainfall-runoff simulation: HEC-HMS
- Hydraulic simulation: HEC-RAS – unsteady flow, 1-D
- Risk scenarios: T=5 y, 25 y, 100 y
- Floodplain mapping: ArcGis 9.2

- Rainfall duration: 2 hours (flash flood characteristics)
- Hydrograph base time: at about 8 hours

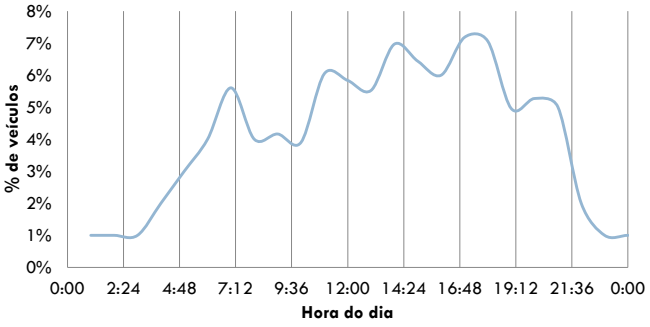
METHODOLOGY

Traffic simulation

- Modelling only in the impacted and surrounding area
- Model *Integration* 5.1
- Road capacity: 700 vehicles/hour.line -HCM *Highway Capacity Manual* (TRB, 2000).
- Velocity limits: 60km/h (main roads); 40km/h (local roads).
- Road length: 49,71 km (*55 links*).
- Flood occurring in two different moments: 10h e 17h.

METHODOLOGY
Traffic simulation

- Vehicles flow according to Belo Horizonte Municipal data (traffic authority) in areas similar to those in the model
- Vehicles flow time distribution according to Belo Horizonte Municipal data



METHODOLOGY
Traffic simulation

EXPECTED RESULTS

Expecting to observe changes over time on:

- household income,
- consumption and displacement patterns

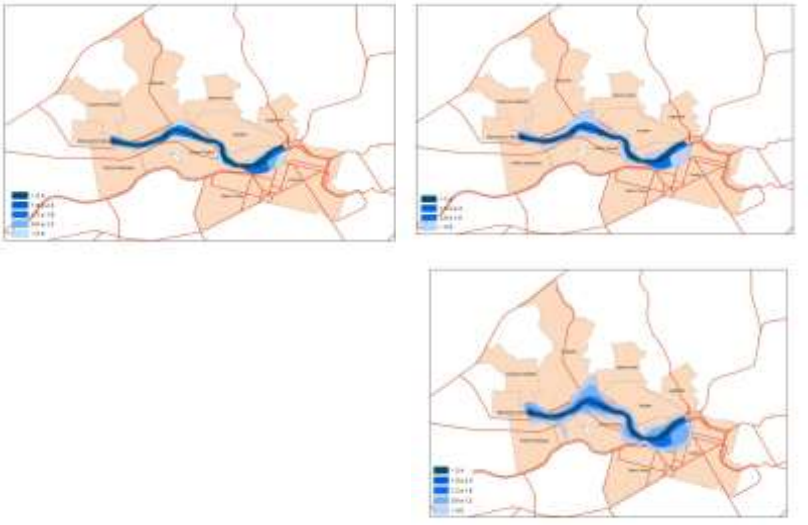
before, during and after flooding

Assessment of flood economic impacts

and the time for recovering

RESULTS

Flood modelling



RESULTS

Direct impacts

	T = 5 y	T = 25 y	T = 100 y
Flooded households	980	1,252	1,919
Flood inhabitants	3,332	4,256	6,525
Flooded firms	624	865	1,288
Road system (flooded links)	13	13	13

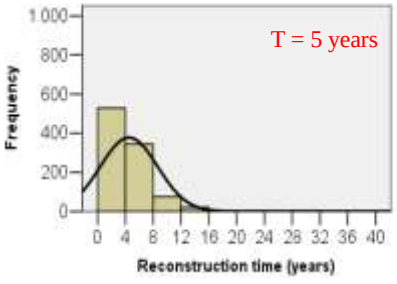
RESULTS

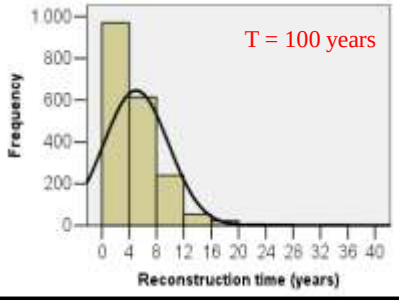
Direct impacts

Risk scenario	Household average income	Direct damage (average)	Recovery time - years (median)
T = 5 y	1,161	5,100	3.6
T = 25 y	1,181	6,100	4.2
T = 100 y	1,248	5,750	3.9

RESULTS

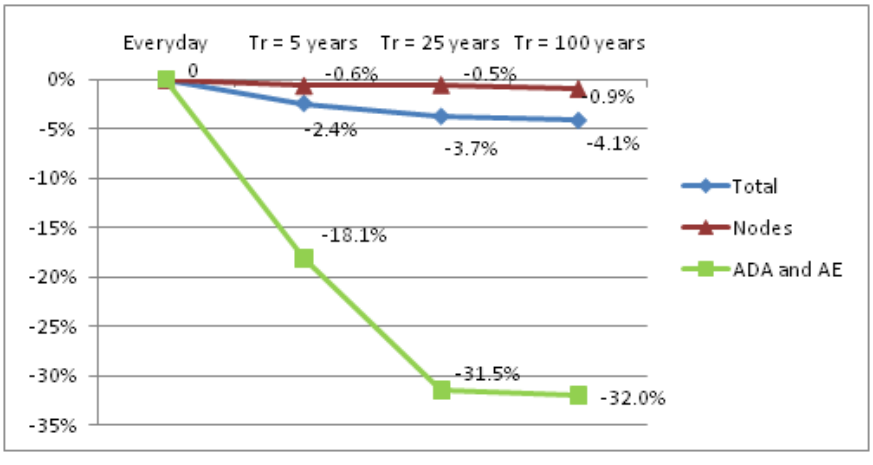
Household recovering time





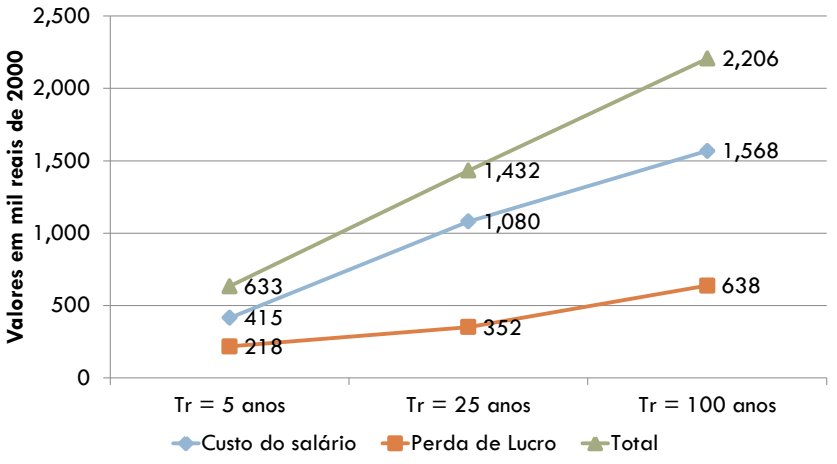
RESULTS

Spatial distribution of impacts: variation on sales



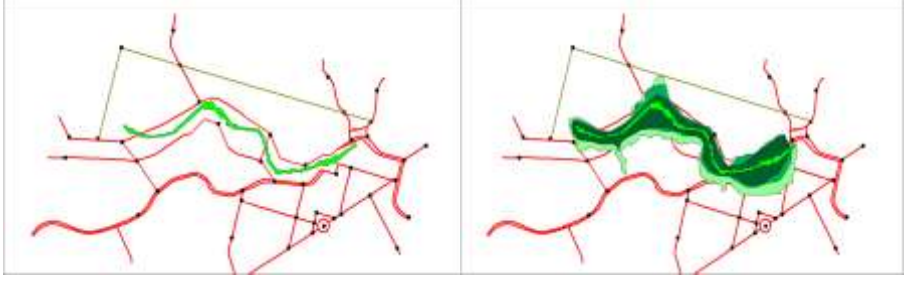
RESULTS

Firm indirect losses



RESULTS

Traffic impact



RESULTS

Traffic impact (T = 100 years, flood at 5 pm)

Variable	Current scenario	Flooding scenario
Traffic jam dissipation time	-	3h 40 min
Average velocity	39.55 km/h	9.07 km/h
Fuel consumption	0.32 l/km	0.754 l/km
CO_2 emissions	742.8 g/min	1759.9 g/min
HC emissions	0.072 g/min	0.131 g/min
NO_x emissions	0.309 g/min	0.422 g/min
Average additional time	-	26.5 min

RESULTS

Traffic impact: costs (Euro) for T = 100 y

	Time	Fuel	Pollutants
Current scenario	100,573	25,511	86 (0%)
T = 100 y	357,558 (256%)	52,516 (106%)	125 (46%)

Researches on floods at UFMG: Conclusions

Conclusions:

- Improving knowledge of flood impacts on households and on the economic system:
  - Direct damages to households
  - Disturbance on expenditures and income fluxes
  - Disturbances to traffic
  - Losses on value added by firms
- Time and space simulation of flood impacts
- Perspectives of application for other environmental studies

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Perspectives

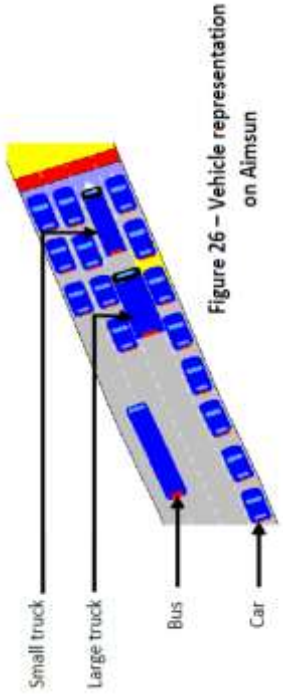

Figure 26 – Vehicle representation on Aimsun

Perspectives:

- Providing elements for improving decision making on flood management
- Developing indicators of flood vulnerability
- Contributing to promote public participation on flood management

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