Modeling urban waters using TONIC model in large metropolitan areas: comparison between Lyon (France) and Ho Chi Minh City (Vietnam)

Introduction

- In a context of climate change and densification of urban centers, large cities have to deal with water management (storm overflows, pollutants loads, impacts on the environment). To make cities more resilient to global change, alternative management through **Nature-Based Solution** (NBS) seems inevitable to achieve environmental and socio-economic goals (Masi et al 2018).

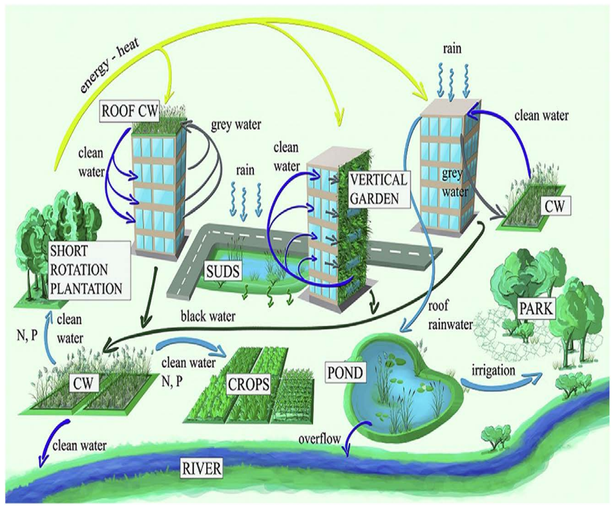

Figure 1 : Rethink the future management of urban waters (illustration Masi et al 2018)

- The aim of the study is to compare **CSO mitigation** in two contrasted large cities by means of **testing scenarios of disconnection with NBS**
- **Lyon City** : is drained mainly by a centralized urban water system. Today, the city of Lyon is invested in the development of alternative urban water management by promoting rainwater management at the source through NBS. The city plans to convert 400 ha of impervious area to permeable one by 2026.
- **Ho Chi Minh City** : the economic capital of Vietnam is in full demographic and economic expansion. The deterioration of water quality is extreme due to a lack of wastewater management strategy. Ho Chi Minh City plans to implement the centralized urban water management system. The relevance of this extremely expensive centralized sewer system choice has to be investigated. Such a system is not necessarily adapted to the particular conditions of this megacity in tropical monsoon zone.

Modelling approach

- The TONIC model **(Tools fOr greeN resilient Cities)** is a simplified hydrological and hydraulic model developed in the laboratory DEEP **(INSA Lyon France)** to provide to municipalities a decision support tool for selecting urban water management strategies based on the NBS implementation for stormwater management (Figure 2).
- The implementation of the model requires description of the watershed (percentage of impervious surface), geometry of the sewer system (diameter, length, slope, number, dimensions of CSO structures or an operating law) and inputs data (population, water per capita, rainfall, infiltration rate).
- The TONIC model works in two phases i) the production phase: simulates the wastewater, runoff water and infiltrated water from surrounding soil ii) the transfer phase that routs the total discharge into the pipes. After a calibration step, the outputs model allows to get the total discharge within the sewer pipes and the total volume and number of spills.

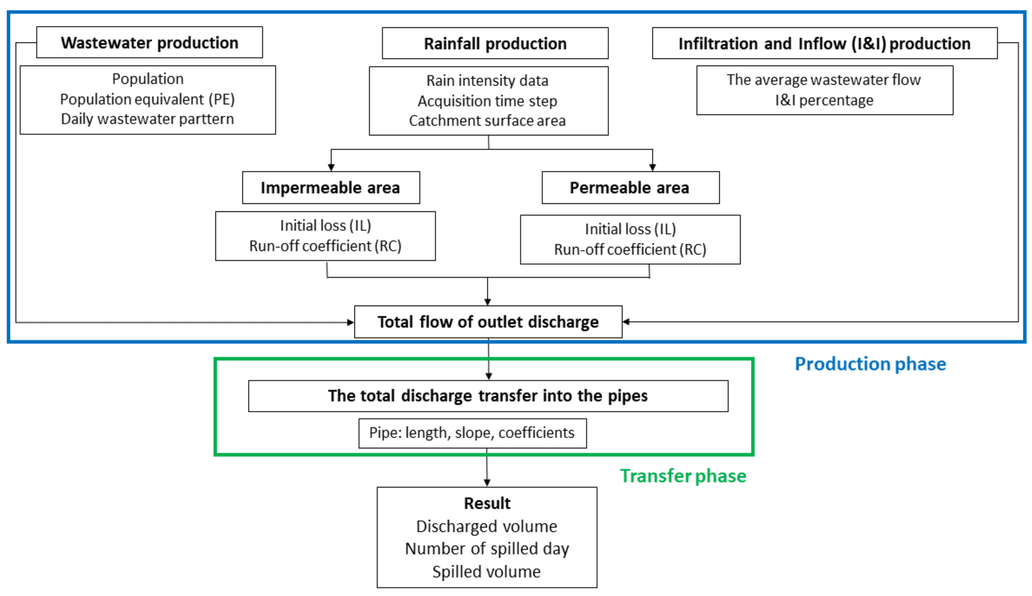

Figure 2 : Flowchart of the TONIC model (from Montoya-Coronado Phd)

References :

- Nguyen TTN et al (2020) Nutrient budgets in the Saigon–Dongnai River basin: Past to future inputs from the developing Ho Chi Minh megacity (Vietnam). River Research and Application 36(6) : 974-990
- Masi F et al (2018) The role of constructed wetlands in a new circular economy, resource oriented, and ecosystem services paradigm, Journal of Environmental Management 216: 275-284
- Montoya-Coronado V (2023) Development of a methodology for disconnecting urban water at the scale of a catchment area. Phd INSA Lyon

Two contrasted metropolitan areas

Ho Chi Minh City

Year	2016	2025	2040	2050
Population (M. inh.)	8,4	11	17,2	23
Number of WWTPs	2	4	12	12
Treatment capacity (10^3 m^3 day^{-1})	171	1,253	2,813	2,813
% connected	10%	57%	82%	61%

Table 1 : Present and future urban water management in HCMC (Nguyen et al 2020)

Lyon City

Year	2020	2030
Population (M. inh.)	1,4	1,5-1,6
Number of WWTPs	12	12
Treatment capacity (10^3 m^3 day^{-1})	1,005	1,005 + NBS
% connected	99%	Runoff disconnection

Table 2 : Present and future urban water management in Lyon (Source Grand Lyon and Insee for population in 2030)

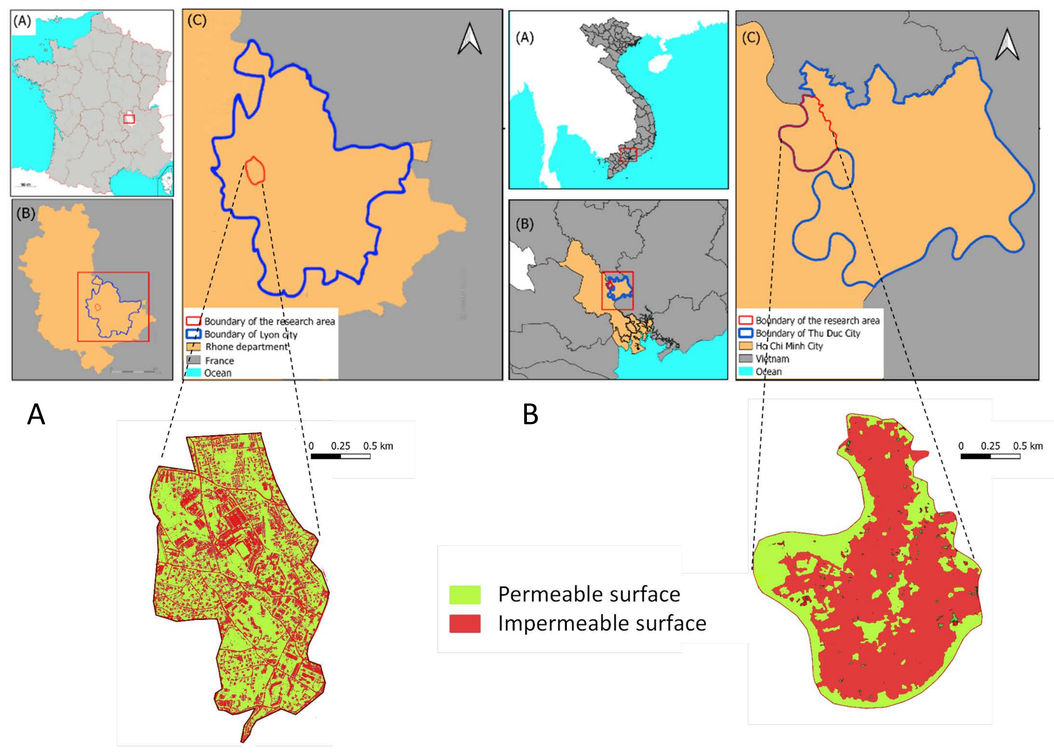

Figure 3 : Map of A) France, and Ecully basin in Lyon City (area, 245 ha, 18 000 inhabitants, impermeable area : 45 %, combined sewage system, one overflow, slope 0,02 m/m, pipe diameter 1m) and B) Vietnam and Thu Duc sub-basin in Ho Chi Minh City (area : 294 ha, 14 827 inhabitants, impermeable area : 69 %, combined sewage system, five overflows, slope 0.001 m/m, pipe diameter 0,8 m)

Results

Table 3 : Scenario of reduction of 10, 20 and 30 % of the impermeable surfaces using NBS.

	Ecully (245 ha) Annual precipitation : ~800 mm				Thu Duc (294 ha) Annual precipitation: ~1 800 mm			
Scenario	Baseline scenario	- 10%	- 20 %	- 30%	Baseline scenario	- 10%	- 20 %	- 30%
Impermeable surface (%)	45	40	36	33,5	69	62	55	48
Total Volume (10^3 m^3)	1 289	1 258	1 233	1 218	338	314	291	268
Spill Volume (10^3 m^3)	44	35	28	24	35	27	20	13
Frequency of spill (day)	26	25	22	20	38	35	26	18

Conclusion

- The effort to remove 30% of impervious surfaces seems promising and contributes to reduce up to 50% of combined sewer overflows
- On the basis of the assumptions considered, the level of effort is comparable in two contrasted cities.
- TONIC model seems to be a promising decision support tool for managers and stakholders to test some scenarios of disconnection and NBS implementation.

Némery J[1], Castebrunet H[2], Montoya-Coronado V.A[2], Thuong TQ[4], Michel A[2], Lipeme-Kouyi G[2], Molle P[3], Nguyen AT[1], Nguyen PD[4], Bui XT[4], Gratiot N[1], Descloitre M[1], Baduel C[1], Caracciolo R[1], Séchet P[5]

[1] IGE University Grenoble Alpes/CNRS/IRD/Grenoble-INP, France
[2] DEEP INSA Lyon, France
[2] INRAe Lyon, France
[4] Centre Asiatique de Recherche sur l'Eau/HCMUT, Ho Chi Minh City, Vietnam
[5] LEGI University Grenoble Alpes/CNRS/Grenoble-INP, France

LYON 2022