Urban storm water management and sustainability

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This paper makes a summary of the present state of the sustainability in the urban stormwater drainage management and relates researchers and end-users questions. It is composed of four parts. The first part points out the existing technical systems while insisting on the contexts of their appearance, it also raises the question of their sustainability. The second part proposes a reference frame with 3 axes "space scale - temporal scale - stakeholders" to examine sustainability. The third part deals with the indicators as tools to express/choose/measure/follow up solutions sustainability. The fourth part broaches the case studies and their possible contributions.

1 Technical systems of stormwater management: assets and tendencies

Stormwater management always formed part of the cities infrastructures. Whatever the time collection or drainage vestige can testify it. The object of this paragraph is not to give an account of it but to highlight our current heritage and the evolutions which led to the appearance of new complementary practices.

1.1 Sewer system

The main technical system remains the sewer network established since the19th century as being the solution to cleanse the Western industrial towns. A combined sewer network to evacuate the effluents of the city was promoted by the hygienists. The pollution of the receiving bodies led to the construction of a wastewater treatment plant and resulted in separating the networks in the zones lately equipped: a network for the collection of waste water and another for stormwater. The first was connected to the combined sewer network or directly to the treatment plant whereas the second rejected stormwater into the receiving bodies. When the flow in combined sewer networks exceeded the capacity of the treatment plant, combined sewer storm overflow (CSO) rejected effluents directly into the receiving bodies.

The city becomes more and more populous but also it sprawls most of the time upstream of the existing networks. The networks go along with it, supported by an economy of scale: under the urban built-up area, an increasingly related network provided with large collectors, has been developed. However the perpetual growth of the networks will cause saturations phenomena and even of “uneconomie” of scale. K Chatzis (2000) distinguishes a paradox from the routine "the more one equips the existing network with important pipes in order to face the floods, the more one facilitates the flow in the network, and consequently, the more the time of concentration is decreased, which tends to increase the peak flow output. Hence a process in spiral is observed during which offer creates its own demand: a part of the capacities of the collectors to be built will be requested in order to absorb peak output caused by collectors in place ".

1.2 Flow control – Urban wet weather effluent pollution

Storage was used to control the flows in order to reduce flood risks. Detention basins have been built downstream of the lately urbanized zones since the 60s and 70s. It is also at that time that one starts to explore the urban stormwater pollution and especially that of the urban wet weather effluent including as well the rejections of the stormwater separate networks as the CSO discharges.
The second means of regulation which appeared at that time was the information supported by computer tools. Information was used for real time control (RTC) of sewer systems. RTC can relate to the simple control of a particular device such as a pumping station. It can go as far as the control of stocks and flows conveyed by the network in order to reduce pollutants discharge, to limit flood risk even to alert in the case of crisis (Chocat et al., 1997). This naturally requires means of rain forecasts and simulating models of sewer systems. This mode of management gives to the network its overall dimension and allows the possibility of an integrated management (Chatzis, 2000). However the available models concerning the working of the triplet network – treatment plant - receiving bodies are at their very beginning.

1.3 Tendencies

Following the adoption of detention basins the paradigm of the stormwater management "to evacuate further and most quickly rain water", which supports the end of pipe solution yields more and more room to a source control principle promoting short cycles, closed water systems management and a slow "evacuation" (Chocat et al., 2001 b), (Burkhard et al., 2000), (GRAIE, 1999). Storage is ensured by various structures, called in France, alternative techniques or compensatory techniques (making up for the urbanization effects). They are detention basin, detention ponds, trenches, swales, wells, porous pavement, etc. These facilities are often superficial and can be integrated in the urban development.
Many stakeholders in Europe and abroad consider that these technical systems satisfy certain sustainability criteria as they allow short cycles, ensure stormwater treatment (by decantation) before discharge and authorize other uses of the equipments (space enhancement, play-ground, etc.) (McKissok et al., 1999, Sibeud, 2001, Baladès & Raimbault, 1990).

The BMP (best management practices) expression, integrates structural measures (mainly works and equipment built) and non structural measures (education, sensitizing to the problems of water and environment, organisational means to manage crises or conflicts) (Larsson & Kärppä, 1997, Urbonas, 1997, Fletcher Marsden et al, 2000). In the UK, in the years 2000, the phrase SUD System (sustainable urban drainage system) describes these closed facilities combining protection against the floods and preservation of the aquatic receiving bodies (Mc Kissok et al., 2001, Andoh & Iwugo, 2002, D'Arcy & Frost, 2001).
Other authors present these techniques like forming part of the green urban infrastructures (Moffat, 2001, Chocat et al., 2003), either the facilities (production or treatment) are distributed and decentralised, either source control is preferred, either waste are recycled or the integrated approaches are privileged.
Thus certain achievements, relatively more recent, do not consider any more rain water as a waste to be evacuated. They aim on the contrary is to use it as raw materials on habitat (watering, flush, etc.) or factory (Fewkes, 1999, Hermann & Schmida, 1999, Appan, 1999).

The technical stormwater management means developments and the paradigms which support them are previous to emergence and to the adoption of the sustainability concept. It rather follows the changes summarized by Harremoës (2003): «changing paradigms during the last 40 years have developed through the following approaches:

1. dispersion : spreading in air, water, and on soil
2. containment : landfills, deposit in salt mines
3. convert: water treatment, purification of flue gas, 'end of pipe solution
4. reuse: recycle
5. no-use: cleaner production, cleaner products, control of demand and control of driving force.

… However, it can easily be shown that there is no single approach that will solve all problems."
The main system of management of water (sewers networks and wastewater treatment plant) is regarded as little even not sustainable (Czemiel Berndtsson & Hyvönen, 2002, Hellström et al., 2000, Chocat et al., 2003,), taking into account its cost but also environmental impacts.

However it is in our opinion difficult to describe a technical solution as sustainable without examining the conditions and parameters of its design and its operation. It is thus possible to conceive and build alternative techniques (green infrastructures) which solves the problems on a space scale of the project and amplify them on a larger scale (Faulkner, 1999), or which generate a diffuse pollution, conflicting uses, etc... In the same way in certain cases a pipe network could meet many sustainable criteria.
We notice in addition that with an exclusively anthropocentric vision of the environment, amounting environmental consideration to that of public health, the combined sewer network in the European cities in the 19th century could be regarded as a sustainable solution. Indeed the later has positively met the needs of social, economic and environmental considerations insofar as it corresponded to a far (an equitable) solution which was developed with an economy of scale and which ensured public health policy. The environmental priorities of the sewer network designers were sanitary. Those of our time start certainly to be a little more ecological. The solutions have evolved since our knowledge, our perception of the problems and the contexts evolve. Taking long term problems into consideration is fatally incomplete. For better apprehending it, it is necessary to multiply approaches and points of view.

2 Sustainable storm water management: framework

This paragraph is specifically dedicated to urban stormwater. This "border" occults two strong relationships:
- stormwater is only one part of water to be managed. The integrated approaches consider water as a whole, runoff water, groundwater, water quality, consumption, waste water, etc. These approaches are currently carried out by scientists. The various statutes of the institutions and stakeholders impose a partition.
- urban stormwater detergent atmosphere and surfaces of the city. The pollutants conveyed and deposited result from other urban activities. Many actions, which go in the direction of sustainability (unleaded petrol for example), exceed the sector of storm water management.

To set an action such as stormwater management it is necessary to define a reference frame. This one delimits the action and rules its interfaces with other actions. This one is three-dimensional axes: space scale, temporal scale, and stakeholders concerned.

2.1 Space scale

It is possible to distinguish two types of space scales which can of course cross:

- territories drained by the natural or artificial systems named catchment
- project or action area, such as district or a specific building work

Catchment area
It is admitted that the relevant territory of the management of water is the catchment area, in other words the surface which receives the rain and restores it in a flow or even in a pollutograph at the outlet. Taking into account the nature of the outlet discharge (ramified sections of artificial networks or natural receiving water) the catchments are often encased entities. However, in urban environment, it is possible to extend or reduce the catchment area by artificially connecting or disconnecting surfaces from certain outlet system. This action remains however tributary of the hydraulic capacity of the work of connection or deconnexion which could be exceeded by strong rains.

Action perimeter
The catchment area does not automatically coincide with the perimeter of the action or with one administrative territory like the city.
The action field can relate to various surfaces which correspond to the following operations:

- updating of a drainage system, sewer pipes or detention basin. The associated catchment area forms certainly part of the environment of the facility, but it constitutes only the requests (input data) of the studied system. According to the nature and other functions' of the work, this operation will be able to concern other actors (integrated detention basin, porous pavement, etc).
- an development operation such as updating of existing districts or the creation of new ones. Here the perimeter is dictated by many and various considerations and the territory thus delimited is equipped with many infrastructures (water, energy, waste, road, etc). The infrastructures could be designed and maintained by multi-field teams (same equipment to manage recreational activities or playground and to manage stormwater for example) promoting strong interactions, at the level the district. But each one stills a part of a larger system (communal sewer network for example) and is supposed to inherit its specificities, principles and requirements.
- - Water management competence is often municipal. However many cities have pooled to manage urban services motivated by an economy of scale. In this case the level of planning, programming or patrimonial management relates to this new perimeter.

Other borders - other territories
At the borders of the stormwater system we also meet interactions with other systems: wastewater (combined sewer network, treatment plant) but also drinking water (sewer exfiltration water, resource preservation).

2.2 Temporal scale

Different approaches are possible to explore temporal scale:
- life cycle stage of the stormwater management systems
- their impacts or response (event effect, cumulative one, long term, current, seasonal, exceptional, etc).

Life cycle stage
Life cycle stages, planning, design/realization, operation, rehabilitation, mobilize various stakeholders. Situations perceptions, concerns and approaches change from one stage to

another. It will be thus the same for the necessary tools, indicators, tables and or "dashboards".
One of the possibilities of delimiting an action thus consists in specifying its territory, its nature (planning, design, management...) and the stakeholders concerned. However exchanges must take place between actions to ensure coherence. Thus those which are planned on the scales of the work or the district are supposed to respect specifications, programs drawn up on more important scales. These programs and specifications are often based on observations and experience feedbacks from accurate scales.

Thus "global thinking" should live on experiments and expertises and "local acting" should be coherent with the overall view.

Time scale of runoff and impact phenomena
The principal objectives of the managers of technical stormwater systems are to fight against the floods and the pollution of the receiving bodies. These two objectives are not inevitably compatible. The purification of the effluents by decantation requires residence times in the works and mobilizes consequently the storage capacities and their availability for successive rains.

Floods
The flood risk approach of the stormwater systems is related to the rainy event, although return periods of rain and return period of runoff (or flood) are not inevitably identical. Managing this risk amounts often to conceiving and/or operating systems able to deal with certain stormwater events. This action also includes crisis management in case of more important events. Taking into account the space variability of the rain, the estimate of hazard (intensity of the rain) requires long local observations. Temporal variability, due to cycles of moisture or drought or with climatic changes, calls into question the scarcity of certain events.

Impact
Temporality differs in the case of urban wet weather effluent. Several scales are possible according to the acute or accumulating effects as they are likely to generate and to which we can add seasonal effects. These ones can be the consequence to the effluents (winter salting) as well as to the states of the aquatic receiving bodies (characteristic of the biotope and life cycle of the micro organisms).
The principal pollutants and phenomena are identifiable. On the other hand their diversity and their interactions on a site often make predictions impossible. Researchers and experts have more and more resort to the in situ experimentation. The observations have various objectives:
- cognitive, aiming at understanding work operation (environmental performance, ageing effect, environmental impact) (JLBK et al., 2000, Pettersson et al, 1999)
- checking, often asked by the organization in charge of the receiving bodies, seeking to quantify the facility effects

The choice and the quality of the indicators are dependant on these programs.

For the small storage facilities (techniques alternative, BMP, SUDs) and apart from the accidental discharges, the long-term effects seem to be predominant. Indeed the pollutants conveyed by surface waters can be undetectable on the event level. Their accumulation, in the sediment and possibly their migration, could on the other hand prove to be alarming.

2.3 The stakeholders

Any urban infrastructure mobilizes various stakeholders at the various stages of its life cycle: decision makers, designers, technicians, managers, institutions, authorizing, controlling, advising and users. Their interests and points of view often diverge, it is the same for their manner of defining the performance or the quality of the infrastructure.

However with their multipurpose character the new stormwater management solutions bring together additional stakeholders at all stages. The design and the operation are particularly concerned. They more and more require a partnership between several specialities: urban planning, drainage system, and sometimes roadway system, parks or recreational activities (Sibeud, 2001, Andersen & Schilling, 2001, McKissok et al. 2001, Perez-Sauvagnat et al., 1998). The users also take part in this set of stakeholders. They rediscover water that the traditional systems (street inlet, underground sewers network) immediately eliminated, except in the case of dysfunction (flood), and they must often learn stormwater variability, in quantity and quality, and understand its incidence on the other uses of facilities (lakes, playground, etc).
Moreover sometimes private statute of certain systems increases users responsibility and poses to the managers of communal system and receiving bodies checking and control questions.

Stakeholders and disciplines multiplicity operates on two levels:
- for the designer or operators of the system the questions of environmental impacts take an increasingly important place. In addition to building work specific abilities (hydrology and hydraulics – abilities traditionally related to the civil engineering), new knowledge, on pollutants, waste and ecosystems, must be acquired and used.
- in the case of multi-purpose facilities, several disciplines meet on the same object. The control, or at least the comprehension, of the interfaces and the interactions requires an important place.

On many operations, information, sensitizing, responsibility, dialogue, coordination, negotiation and governance work their way to the decision-making processes, design and operation. However now this does not constitute the dominating model.

Governance question is put on several levels:
- at the law or regulation level (communal decrees, financial incentives, …). How is it possible to devise regulations adapted to local contexts? Which are the means to enforce planned regulations?
- stakeholders concerned by these technical systems, before, during and after the realization of the works. How can one organize the dialogue? With which means?
- the follow-up of the technical and sociotechnic systems in the time which covers earlier subsequent actions (owners and designers information and sensitizing) and ("dashboard", observatory, experience feedback, etc.) (Herin, 2000, Chapgier et al., 2000, Baladès & Garrigou, 1992). Which are the practices and the necessary means?

3 Indicators

Chapter 40 of Agenda 21 propose the use of indicators in implementing sustainability development.

The indicators represent an attitude which makes it possible to hope to do away with the concept ambiguity. This attitude can be related to a "technocratic" request. Faced with the concept imprecision the decision makers and the technicians would wish to acquire a series of characteristics measurable, which can be reproduced in time, comparable between geographical areas, enabling an outlook that could be a reference or a or consensus, on situations and their evolutions (Zaccaï, 2002).

3.1 General information on indicators

It is easy to note the diversity of the definitions related to the sustainable development indicators.

According to OECD, (1993) indicator is a parameter or a value deduced from other parameters, which provides information on a phenomenon / an environment / a zone. The indicator has a synthetic significance of a range extending beyond the properties directly associated to its value.
According to this organization, the difference between an indicator and an index are due to the fact that an index is a set of parameters or indicators aggregated or incorporated.
According to IFEN (1999), an indicator is a data which was selected from a more important statistical unit because it has significance and particular representativeness. For example, the national CO2 emissions constitute an indicator of the contribution of our country to the greenhouse effects.

E. Zaccaï (2002) reminds nevertheless that certain fields lend themselves better than others to modelling and quantification. Economic flows, demography are examples. In the field of environment the physical data are appropriate for all kinds of quantified measurements. But there are always possibilities of discussion between the selected indicator and the problems to which it is referred to.
The European project Pastille (2002) identifies several roles allotted to the sustainable development indicators.

- Understanding sustainability: identification of relevant issues, current state and future trends, education and information giving
- Solving conflict: coordination and liaison, mediation, discussion about different values
- Supporting decision: definition of objectives and goals, identification of action requirements, benchmarking
- Involving stakeholders: participation and involvement, communication, initiation of discussion and awareness raising
- Directing: monitoring and evaluation, assessing performance, interpretation, guiding / controlling

According to J. Theys (2002) building indicators aiming at achieving all these roles at the same time, is doomed to failure. Pastille project draws up the sustainable indicators profiles:
- Levels of decision making (strategic, programme or project levels)
- Different tools: benchmarking, appraisal/assessment, comparison, or monitoring
- Typology of indicators suggested by DPSIR model: driving force, presses, state, impact, response, others
- Purposes of indicators among the 5 possibilities quoted above

An indicator is often built starting from various raw data and is supposed to have certain characteristics (Pastille, 2002). Considering the multidimensional character of the sustainable development the indicators are numerous. To handle and use them requires obviously a multi criteria analysis. Aggregating these indicators or "indicator set" in only one index is not always well appreciated since it erases, by compensation or by weighting, information which the indicators carry.
Other approaches (non compensatory method) are thus privileged, like graphic methods or the methods which rank solutions (Bertand-Krajewski et al., 2002, Ashley et al., 2002a).
Let us note that indicators but also multicriteria methods are supposed to take into account data uncertainties. Those are not negligible in urban hydrology and are propagated in the computation models. Bertand-Krajewski et al. (2002) illustrate the incidences of uncertainties in the performance evaluation of a detention basin.

3.2 Sustainable storm water management indicators

The scientific and technical literature is rich in articles and publication on the sustainable stormwater management. The majority of these materials formulate the question or support an approach like storage and infiltration of stormwater or their reuse (Lawrence et al., 1999, Larsson Kärppä, 1997, Burkhard et al., 2000, Urbanos, 1997, Chocat, 2002, Bertrand-Krajewski et al, 2000, Rijsberman & van of Ven, 1999). Many of them give examples of projects or achievements (Sibeud, 2001, McKissock et al., 2001, Andersen & Schilling, 2001, …) or compare options by using criteria specific to the studied project (Aalderink & Icke, 1998).

Whatever the space scale considered, publications relative to the sustainable stormwater management indicators use often a downward analysis which starts from criteria, develops them in sub-criteria and indicators and ends in the data required to the evaluation. We describe three approaches which are different by their objectives. The first one is interested in an infiltration tank and aims at comparing alternatives of design or of management. The second one aims analyzing and comparing stormwater systems. The third approach builds and uses indicators to compare technological options.

Indicators related to a stormwater infiltration tank
A multi-indicator approach was developed in JP Bardin et al (2002) to allow comparisons between several alternatives at the design stage or during working phase.
17 performances were defined (table 1). Considering each performance, one or more complementary indicators or several options of the same indicator were proposed in accordance with different levels of data availability. No evaluation method was dismissed. The use of expertise, modeling, on site measurements, …was thus integrated in the evaluation process when necessary. On the contrary, for some performances, the lack of data or information was so important that no indicator was explicitly proposed.

Table 1 Performance indicators and present conditions

Performance	Number of ind.	Evaluation modes	(1)
1. Low flooding - frequency and quantity	2	- Quantitative assessment by modeling	TC
2. No pollution of water resource	1	- Quantitative estimation from average generic data or from on-site measurements and - Qualitative assessment (expertise) for vulnerability assessment	TC
3. Contribution to groundwater recharge	3	- Quantitative assessment by modeling	TC
4. Little use of raw material	-	-	In C
6. No soil pollution	2	- Quantitative assessment by on site measurements	TC
7. Trapping of solid waste	-	-	In C
8. Durability	1	- Qualitative based on expert rules estimation	CI
9. No disturbance of other systems	-	-	In C
10. Secure and safe for users	1	- Quantitative estimation from average generic data or by on-site measurements	TC
11. Secure and safe for staff	2	- Quantitative estimation from average generic data or by on-site measurements - Quantitative assessment by on site measurements	TC
12. Low cost systems	1	- Quantitative specific estimation	CI
13. Preserve / encourage economic activity	1	- Qualitative based on expert rules assessment	CI
14. System's adaptability	1	- Quantitative assessment by modelling	TC
15. System with other functions		- Binary assessment	TC
16. Users' perception	-	-	inC
17. Recyclable systems	-	-	inC

(1) Present indicator condition: (TC): Totally computable, to improve with use / (CI): computable but requires improvements / (in C): in construction .

MISTRA program

Within Swedish project MISTRA (Malmqvist, 1999), criteria to analyze and compare systems, were classified into 5 categories: (1) hygienic and of public health, (2) social and cultural, (3) environmental, (4) economic (5) functional and technical. For each criterion one or more indicators were suggested. For most of the indicators the contribution to various environmental effects and resource utilisation by the urban water and waste water used in Sweden today is presented. These values are compared to the impact of Swedish society in total (normalisation) to demonstrate which criteria are the most critical ones with regard to the water and waste water system (Hellström et al, 2000). Priority set of criteria and associated methods are given in the table 2

Table 2 The priority set of criteria and the associated methods for evaluation for the systems analysis project of the research programme « Sustainable Urban Water Management" (Hellström et al, 2000)

Criterion	Method for evaluation
Health and hygienic criterion	
Risk infection	Microbial risk assessment
Social and cultural criterion	
Acceptance	Action research and assessment scale
Environmental criteria	
Eutrophication Spreading of toxic compounds to water Spreading of toxic compounds to arable soil Use of natural resource	Life cycle assessment, computer-based modelling, material flow analysis, and exergy analysis
Economical criterion	
Total cost	Cost-benefit analysis
Functional and technical criterion	
Robustness	Functional risk analysis

SWARD project

In the UK Sustainable Water industry Asset Resource Decision (SWARD) project is interested in 3 aspects (Ashley et al., 2002b):

- decision mapping to determine how decisions are currently made by the water service providers (WSP) and how sustainability issues are included
- production a guidebook as a tool to help WSPs apply the concept of sustainability. The guidebook contains a framework that comprises a set of decision support processes that can be used to explicitly incorporate sustainability consideration into decision-making procedures through the use of sustainability criteria, indicators and processes.
- demonstration of the guidebook use via a wide range of case study examples

The primary criteria are given in table 3

Table 3 The SWARD primary criteria (Foxon et al, 2002 in Ashley et al, 2002)

Social criteria	Impact on risks to human health Acceptability to stakeholders Participation and responsibility Public awareness and understanding Social inclusion	**Technical criteria**	Performance of the system Reliability Durability Flexibility and adaptability
Economic criteria	Life cycle costs Willingness to pay Affordability Financial risk exposure	**Environmental criteria**	Resource utilisation Service provision Environmental impact

Based on cases studies these primary criteria are developed in secondary criteria and next in indicators. Methods or approaches are suggested to estimate the indicator. According to the case study certain primary criteria are not developed. The table 4 give the indicators for the study following case: sustainable urban drainage systems (SUDs) versus conventional drainage.

Table 4 SUDs Case study in SWARD guidebook (Ashley et al, 2002b)

Primary criteria	Secondary criteria	Indicators
Economic area		
Life cycle costs (includes resource, extraction, production, etc.)	Capital cost Operational cost Maintenance cost Decommissioning cost	Average costs Annual costs Annual costs Average costs
Financial risk exposure	For capital investment	Risk of loss associated with investment – sensitivity analysis
Environmental area		
Resource utilisation	Land use Energy use Chemical use Material use	Land used area in km² Energy use for construction (kW) Energy use per Megalitre treated (kW/m3) WTP or on site (herbicides) (Litres/yr) Total material requirement (tonne/yr)
Environmental impact	Impact on water Impact on biological diversity	Watercourse quality (% of watercourse with “good” ecological status) No. of keys species at risk : habitat loss, low flows No. of key species introduced to area due to development : habitat creation
Technical area		
Performance	Quality of receiving water Flooding	Compliance with required standards in tests performed throughout the yr (%) No. of water quality complaints per yr (e.g. aesthetics) No. of floods/ overloads per yr from each drainage option No. of properties / persons affected
Reliability	System failure	Likelihood of system failing
Durability	Design life of system	No. of yrs system expected to operate
Flexibility and adaptability	How flexible and adaptable is the system? Ability to add to or remove from system	Level of accommodation in design : potential to accommodate future changes (qualitative) Cost of adding / removing from system in response to change
Social area		
Impact on human health	Risk of infection	% of population at risk from pollution
Acceptability to stakeholders	Perceived health and safety Perceived environmental impact	% of users with concerns about injury, drowning, risk of infection % of users perceiving a positive environmental impact
Public understanding and awareness	Stakeholders information	Will the information be provided about wider ‘water’ issues involved? Will awareness be raise measurably (% of knowledge in local community). Can the option be used to demonstrate a new method to other developers?
Social inclusion	Access to waterbodies/watercourses	Is access increased? What are the perceived benefits of clean rivers, or the creation of new water features?

In addition to the downward analysis, criteria/under criteria/indicators/ parameters, these three examples share other common points. They require very elaborate data and evaluation tools

(simulation models, surveys, etc.) which are justified for research projects whose mission is to build and spread knowledge but which are not always easy to use by end-users.
Moreover they really identify the evaluation difficulties which can have various origins: assumptions on the facilities operation, data quality, indicators quality, parameters of the multicriteria analysis methods.
If the indicators of comparison can be regarded as a tool to measure sustainability, the practical cases studies remain the "laboratory" where one learns how to enrich sustainability perception or to improve indicators construction.
A complementary approach consists in starting from case studies, to examine the practice of sustainability and to feed, in return, the theoretical speech and tools.

4 Learning sustainability while making: the case studies?

Sustainable development is accepted unanimously by various stakeholders, decision makers, technicians, citizens, scientists. On the other hand, its contents on local scales and more precisely in the case of the urban infrastructures and stormwater management are not well defined. This difficulty in defining sustainability in these scales is due to the interactions between various dimensions technical, economic, social and environmental, to controversies and to diverging points of view reflecting the situation complexity. The bibliography is rich in case studies describing a quite precise operation. In addition various studies, actions or research programs adopt an approach based on case studies for better understanding and defining of sustainability (CERTU, 2002, association 4D (web site), Cost C8 (web site) Ashley, 2002b).

Beyond the value of example or the communication on innovating approaches, the analysis of these case studies makes it possible to identify stakeholder's perceptions of the sustainability, their manner of implementing it or of measuring it (indicators). This analysis requires however information which covers the history of the case and its context and which comes from various sources. It is naturally not the case of the majority of the articles or forms prepared by a well defined author who describes a life stage of an infrastructure without evoking its history or its evolution. A practical action requires certainly a reference frame: well defined scale of time, scale of space and stakeholders, but for better understanding it and to study its sustainability it is important to widen the scope and to examine the interactions with other scales.

The practical cases illustrating the on site complexity allow to observe and try out approaches, tools (indicators, "dashboard", etc.) or of governance forms. They reveal the strong interactions (common support, exchange of matter, etc.) which can take place between various urban infrastructures (water/park, energy/waste, etc). These interactions encourage adopting a holistic vision which can result in modifying the sector indicators value. Thus the high cost of the drainage systems will be prove to be acceptable for the district area if these facilities take part in architectural development.

The difficulty, on the other hand, inherent in these objects lies in their specificities. Each case is indeed unique and what is transposable / capitalizable corresponds to the approaches and methods.
The partnership between scientists and end-users aims, moreover, to formalize knowledge from practices or hands on experience.

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