Paper n° 537: The TERRACES project – A collaborative work to understand the role of vegetative green roof in refreshing the urban ambiances

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Dated: 15 May 2015

1. Introduction

In order to improve the sustainable urban design according to health, environment, energy and climate issues, the integration of vegetation in the cities is promoted. Urban greening is not only a fashion and its success is based on various at the same time social arguments [*Emelianoff, 2007; Cunha, 2009*], economic, sanitary and environmental: extension of the life cycle of the roof [*Wong et al., 2003; Teemusk and Summon, 2009*], decrease of the rate of CO2 in the atmosphere [*Emilsson et al., 2007*], esthetic attraction of the building and the increase of the urban biodiversity [*MacIvor and Lundholm, 2011*] and the mitigation of the urban heat island [*Takebayashi and Moriyama 2007; Alexandri and Jones, 2008*].

The vegetative green roofs (VGR) could represent a serious opportunity to reach the green and dense compromise, both for the buildings construction and rehabilitation process in the existing dense city centers.

However, urban experts require evaluation and design technical means to promote VGR in their projects, consistent with the existing urban layouts.

Furthermore, the knowledge about green roofing technique is not yet well accomplished because of the multiplicity of VGR typologies and layer intrinsic properties, the complexity of the multi physics transfer phenomena and the interactions between green roofs and their surroundings [*de Munck et al. 2013*]. The evapotranspiration process is the main heat sink of the energy budget for green canopy but is not easy to assess.

2. The abstract

Currently, different urban planning strategies are proposed to cool the micro-climate (especially in summer) acting on the temperature, wind and humidity. The frequently cited cooling devices are physical proceedings such as the vegetation cover expansion. The most prominent examples are the living walls and roofs. The proposed project intends to deeply develop the scientific analysis of the performance and impact of vegetative green roofs (VGR) on urban climate, environment and health.

The scientific approach aims to achieve three main objectives: task 1 is to assess the refreshing potential of a VGR; task 2 to develop relevant indicators dedicated to VGR environmental impacts; task 3 to establish a link between VGR performance and spreading potential in urban zones.

The task 1 aims at qualify and quantify the changes in the urban energy balance induced by the introduction of vegetation. These modifications are associated with the physical properties of green surfaces and increased evapotranspiration. Estimation of evapotranspiration by VGR is important to assess the cooling potential of this system, in nowadays climate conditions but also under climate change GIEC projections. Several criteria will be used (vegetation type, substrate thickness, geographic context...).

The task 2 is to evaluate health and environment risks and benefits of VGR in their local urban context. These indicators can then help create an index that can be used by planners and decision makers. Analysis will be done

specifically on water to evaluate potential metal and microbiological contamination.

The task 3 is to allow mapping the potential of VGR at the scale of an agglomeration using a building typology classification This latter will be based on land use database, technical characteristics of the buildings (roof slope, age, etc.) and urban data (PLU, architectural history, etc.). This representation will be coupled with the results of tasks 1 and 2 in order to obtain thematic maps.

This communication addresses the methodology selected, the experimental protocols developed and the first results on the three tasks.

3. The methodology

3.1 Task 1 / Assess the refreshing potential of a VGR

The aim is to qualify and quantify the changes in the urban energy balance induced by the introduction of vegetation. These modifications are associated with the physical properties of surfaces and increased evapotranspiration. Indeed, one of the reasons of the temperature increasing in cities is the reduced evaporation from the urban surfaces.

Most of the studies on the role of vegetation in town are based on simulations at mesoscale and the result often depends on numerous local parameters as the regional climatic characteristics, the type of building or the composed hypotheses [*Santamouris, 2012]*. This makes very difficult the comparison or the generalization of the conclusions. But all the published works is unanimous on the positive contribution of the vegetated roofs on the thermal of buildings and to a lesser extent the reduction of the temperatures. Estimation of evapotranspiration by VGR is important to assess the cooling potential of this system, in nowadays climate conditions but also under climate change GIEC projections. The magnitude of changes will also depend on the characteristics of the device (vegetation type, substrate thickness, etc.) but also their geographic context. This task is organized in 3 sub-tasks (Figure 1).

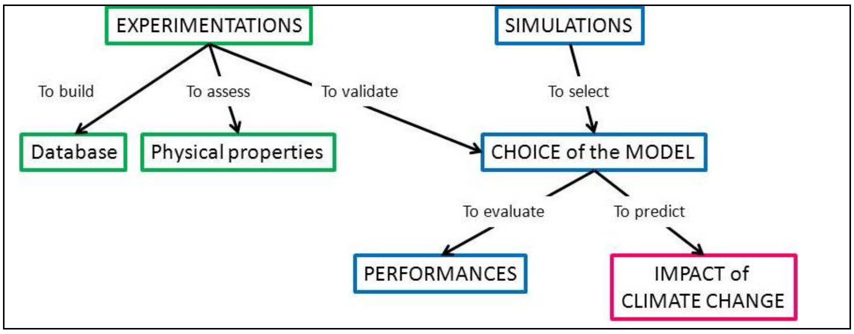

Fig. 1 Organization of task 1.

It is then essential to measure, on various experimental sites (Figure 2), the parameters necessary for the validation of the model (**sub-task 1.1**). Besides the need for data for modeling (**sub-task 1.2**), these observations will also allow to constitute a database on the physical properties of the VGR, still little known and which can be useful for the whole scientific community. A study of the evolution of the precipitation and the temperatures on 3 target cities within the framework of a climate change (**sub-task 1.3**) will allow a better adequacy between the choice of the nature of devices, their number and their location. In this frame, the use of the scenarios of the project GICC DRIAS will be relevant [*Lémond et al, 2011].*

Nancy

Nantes

Trappes

Fig. 2 The 3 experimental sites, Nancy, Nantes, Trappes.

3.2 Task 2 / Develop relevant indicators dedicated to VGR environmental impacts

As they are sometimes called, “living roofs” are alive and can interact with their environment. If this technique is used at a wider scale in coming years to refresh cities (Figure 3), it is important to check whether they could induce some environmental or public health inconveniences.

Fig. 3 Brooklyn Grange, Urban rooftop farm, New York (ghassancontracting.wordpress.com).

Concerning environmental impacts, green roofs can provide a support for vegetal and animal biodiversity development [*Schneider, 2010; Tonietto et al., 2011; Fernandez-Canero et al., 2010*] for instance. The invasive potential of green roof plants is sometimes mentioned but little information is available [*Butler et al., 2012*]. Besides, green roofs can have a positive impact on human welfare [*Oberndorfer, 2007*] but could also present some health hazards linked to water quality or allergenic plants.

The objective is to evaluate health and environment risks and benefits of VGR in their local urban context. These indicators can then help create an index that can be used by planners and decision makers. Analysis has been done specifically on water to evaluate potential metal and microbiological contamination.

An extensive study will be realized on water quality aspect in a context of green roof water reuse. Metals and pathogens will be analyzed in waters coming from different experimental roofs (one gravel roof and several green structure’s) built in 2010 on the LRPC de Nancy building. It will allow evaluating the impacts of different materials on potential metal and microbiological contamination.

3.2 Task 3 / Establish a link between VGR performance and spreading potential in urban zones

The goal here is to develop a methodological framework to map the green roofing potential at the scale of an agglomeration by using a building typology. This typology will be based on land use database and technical characteristics of the buildings (roof slope, structural strength, age, etc.) and urban data (PLU, architectural history, etc.). This representation will be coupled with the results of tasks 1 and 2 of the project to obtain thematic maps and is organized in 3 main sub-tasks (Figure 4).

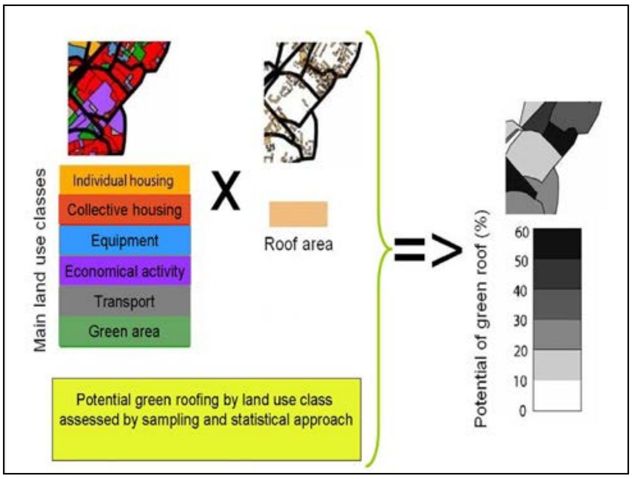

Fig. 4 Potential green roofing assessment method: general principle.

Sub-task 1: Assessment and mapping of potential green roofs for Paris urban area

At the level of the Paris urban area (415 municipalities), the historical MOS- land use databases [*IAU, 2008*] and BD TOPO® – buildings database [*IGN, 2011*] will combined to define several “building classes”. For each of the considered buildings classes, statistical sampling will identify a corresponding green roofing potential. These green roofing potentials will then be calculated for each municipality and mapped at Paris urban area scale.

Sub-task 2: Detailed study of "updatable" green roofing potential at the scale of the municipality

A municipality of Paris urban area characterized by an urban diversity and a high overall green roofing potential (calculated in task 1) will be chosen. In this municipality, the study will spatially be detailed at the quarter scale. Urban scenarios will be built by taking into account: (i) existing green roof; (ii) new or retrofitting projects, and (iii) local public policies.

Sub-task 3: Transferability analysis of the method to other cities

An inventory of databases developed in other French cities and similar to MOS will be done. Then a list of requirements for implementing the method in any urban area will be established.

Acknowledgment

TERRACES project (ImpacT of vEgetative Roofs on uRban Ambiances: Cooling effects, Environment and Spreading) consists of four partners (Cerema - Directions territoriales Est and Ile de France, CSTB/CAPE and GEMCEA) and is financially supported by the ADEME.

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