PARIS/ILE-DE-FRANCE REGION FACING CLIMATE CHANGE

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↑↑ TOC

FIGURE 1 : Snapshot from the 3D video simulation Flooding Paris.
SOURCE : IAU îdF

INTRODUCTION

One of the major goal of the Paris/Ile-de-France Region is to prevent the effects of climate change. To achieve this goal there are two main responses: mitigation with a focus on the reduction of greenhouse gas emission; and, adaptation with a focus on risk management and prevention. These responses have had direct effects on the way the Paris/Ile-de-France 2030 regional master plan was prepared and designed. We have identified that flooding, storms and heat waves are the main risks facing the region and we are exploring solutions to manage these crises. Solutions exists that require large scale actions and a high level of coordination making them difficult to implement in a metropolitan area.

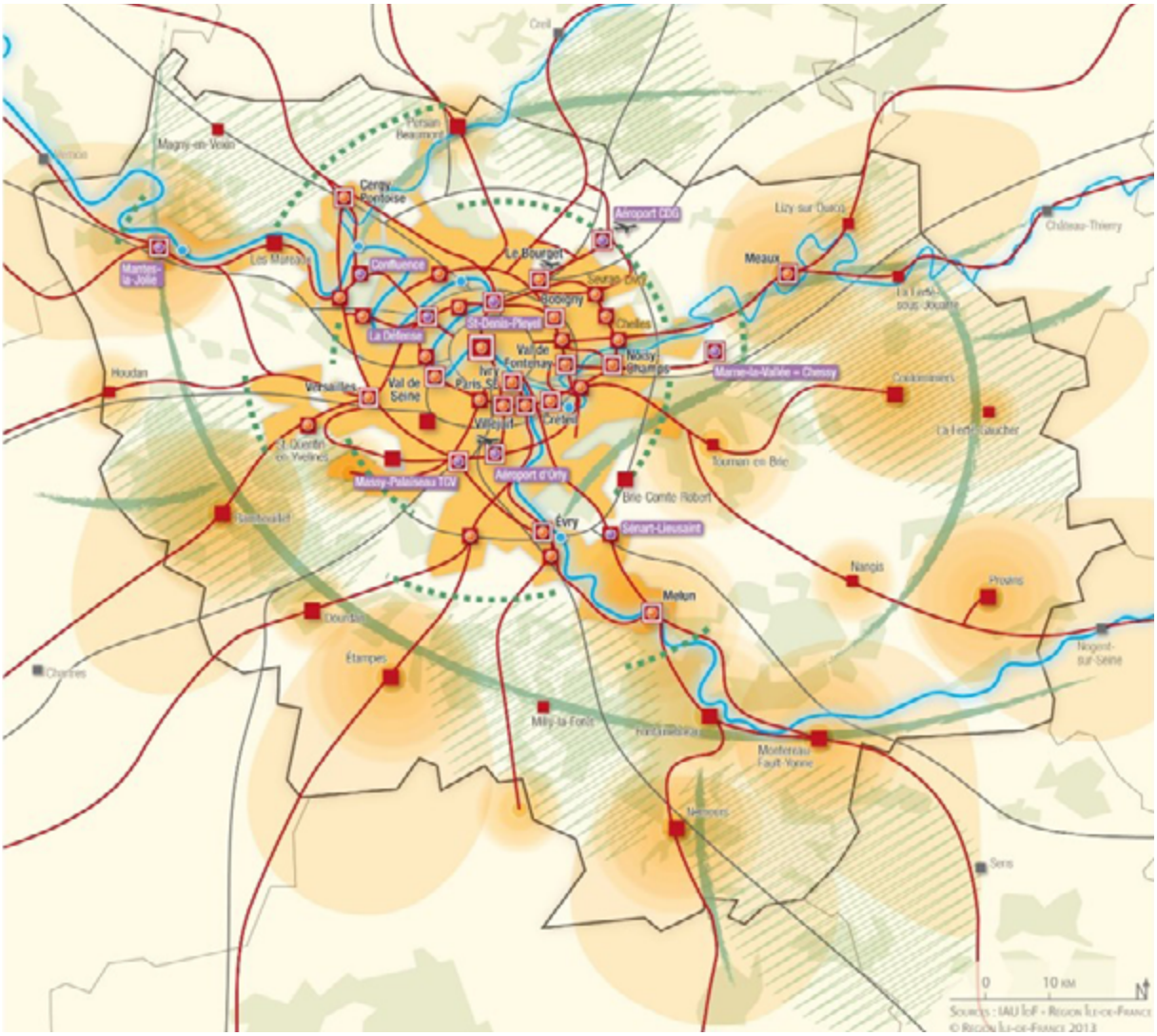

FIGURE 2: Paris/Ile-de-France Regional spatial strategy

PARIS/ILE-DE-FRANCE 2030 REGIONAL MASTER PLAN: A TOOL SHAPED FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

The Grenelle de l'Environnement, a main French legislative reform adopted during the beginning of this century, makes ecological transition a major objective of urban planning documents. Additionally, the Paris Agreement for Climate change was a key moment for the international community to define strategic objectives regarding climate change challenges. The recent environmental awareness initiatives by public authorities and citizens make it a political issue, but, in fact, the Paris region has been working on this topic for decades.

Several documents have been adopted regarding climate change: the Ile-de-France Regional Climate Plan; the Regional Air, Energy and Climate Scheme; and, the "Ile-de-France 2030" Regional Master Plan (SDRIF adopted in 2013). These planning documents have been drawn-up to respond to the level of vulnerability already observed and the results of climatological, socio-demographic, and urban forecasting. The Ile-de-France 2030 regional master plan defines the spatial strategy for the development of the global metropolis. Prepared in a collaborative manner, it represents a contemporary answer to tackle climate change issue at the scale of a large metropolis.

The socio-economic development of the Île-de-France has a strong impact on its energy requirements, a key factor for greenhouse gas emissions. Ile-de-France, which hosts 19% of the France population and 30% of the National GDP, represents only 15% of the national energy consumption. The expansion of the service sector, which consumes less energy than industry, and the density of the urban fabric explains much of the relative advantage of the Paris/Ile-de-France region in terms of energy and greenhouse gases emissions. Despite this configuration, the emissions of greenhouse gases in the Paris region continue to rise, even though a stabilisation has been observed at a national level. To reduce mobility needs, and then greenhouse gases emissions, the regional master plan focuses on a compact, dense and multi-polar region. It includes policies and spatial development strategies to develop urban spaces adapted to renewed mobility, with less dependency on the automobile, and to boost new sources of renewable energy. The mobility requirement forced rethinking by developing alternative modes of transport (cycling, walking, public transportation, shared cars…).

The inner suburbs, characterised by a dense urban fabric, and the outer suburbs benefit from improving access to public transit and active modes of transport. The Greater Paris Express metro line project - 205 km long with 68 new stations in the suburbs is one of the larger urban project in the world – also connects dense and diverse neighbourhoods around the stations using alternative mobility modes (public transport, bicycle paths, traffic calming of motorised vehicles on boulevards…). This key project is intended to renew the urban fabric, increase job and housing opportunities inside the existing urban areas, and reduce the need of suburban extensions. To make it possible, the plan identifies and defines specific regulations to encourage urban intensity in the existing urban fabric, especially within the 2 km surrounding of the main metro and railway stations, creates new green and transportation connections, and sets minimum densities for the urban extensions.

Also, the development of a circular economy is encouraged to reduce the mo-

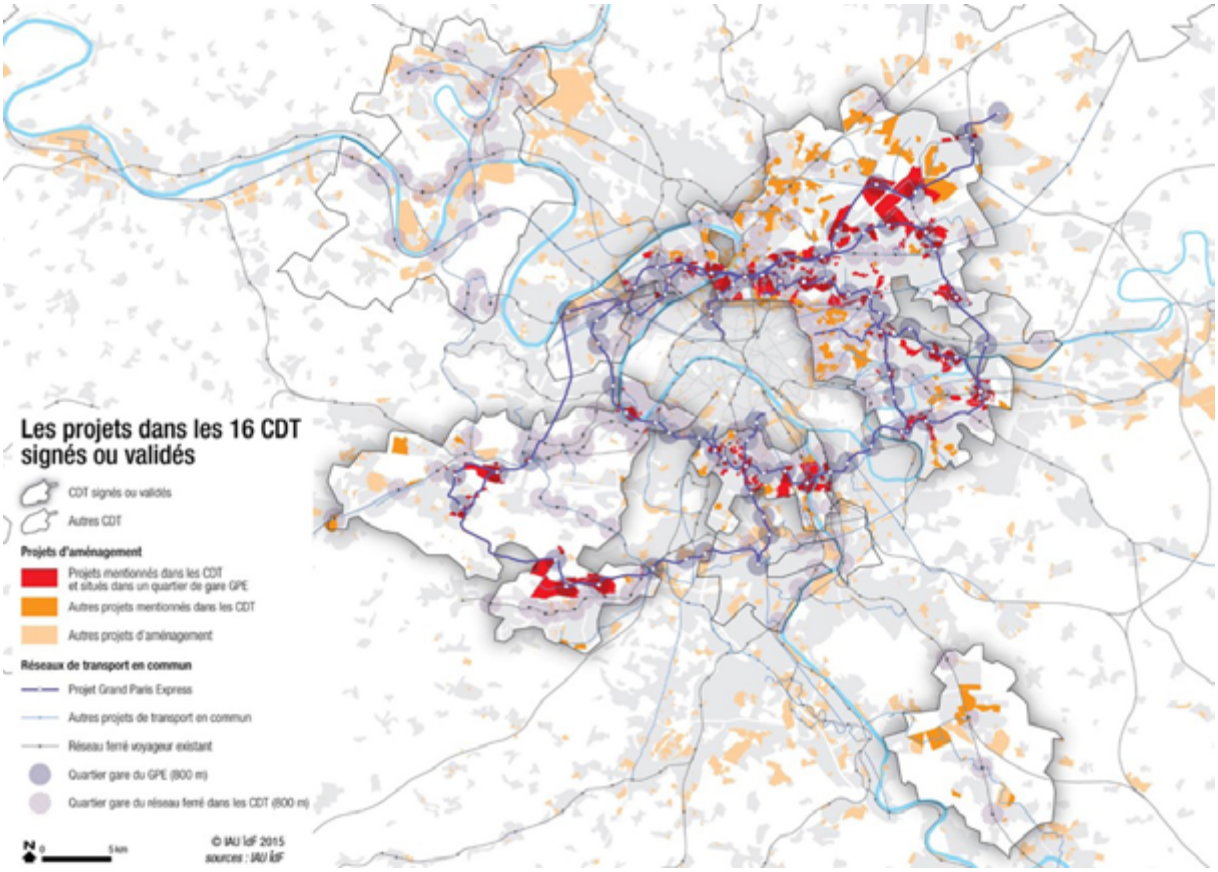

FIGURE 3: Greater Paris Express, a strong infrastructure to reshape the metropolis through large urban projects around metro stations

bility of goods. Also redeployment of the logistic multimodal platforms is promoted to take into consideration the effect of the smart systems on commercial delivery. Priority is assigned to rail-river-road intermodal transport services.

The priority given to public transport aims to reduce the consumption of fossil fuels, and the urban densification facilitates the use of geothermal heating. Moreover, the regional master plan encourages localized networks to supply energy by allocating land for urban service facilities (oil depots, associated liquid hydrocarbon pipes, storage and natural gas pipelines, strategic lines for very high voltage electric transport network, etc.). These reservations for equipment avoids their rejection in the outskirts, which if allowed to happen would increase consumption of space and require more transport. Furthermore, the necessary rights of way have been reserved for the deployment of equipment to link local renewable energy production and recovery, as well as their distribution, particularly through heat networks.

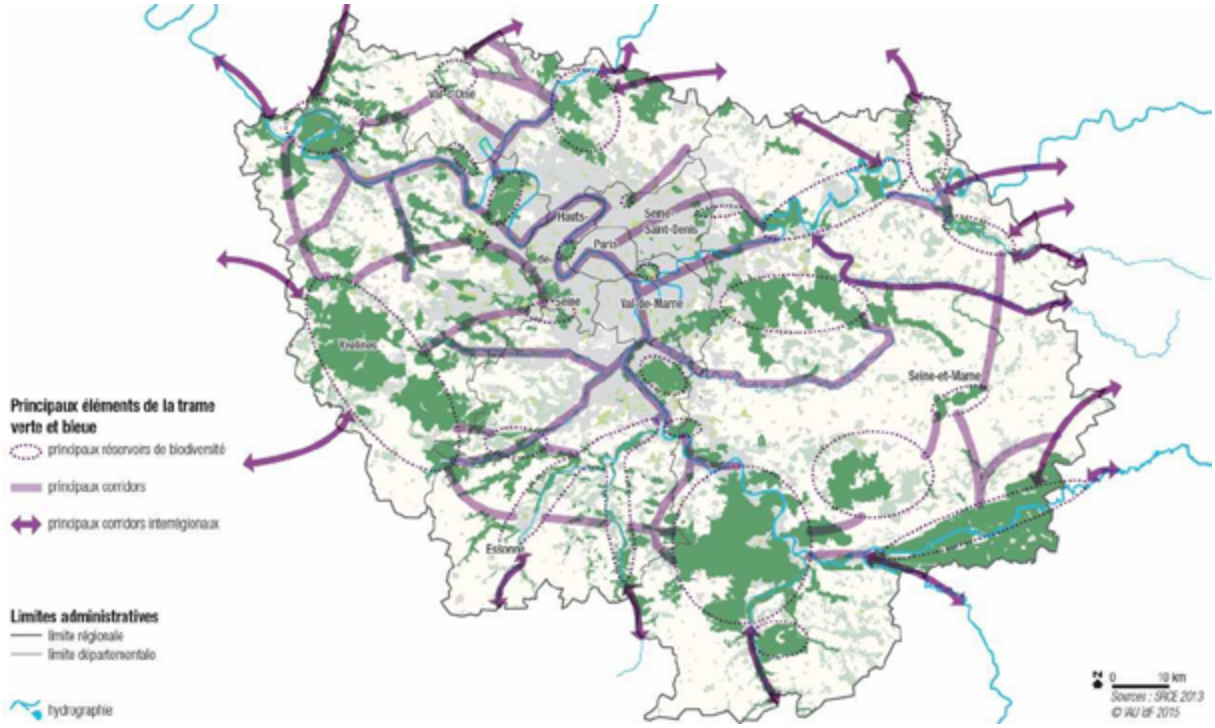

FIGURE 4: ↑ Biodiversity corridors and Agglomeration green grid. SOURCE : IAU îdF

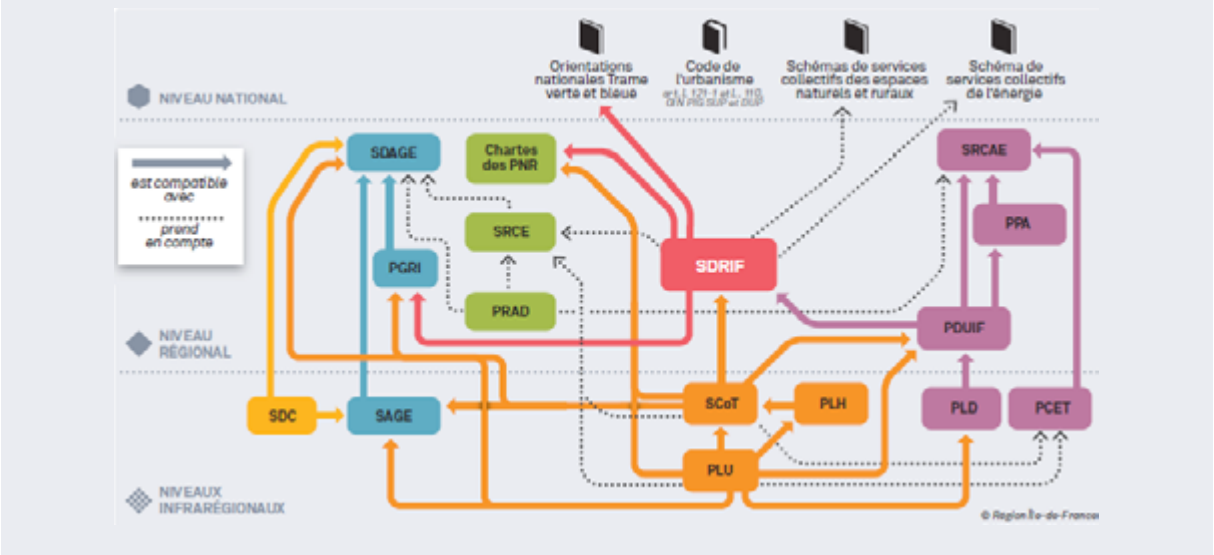

FIGURE 5: ↓ A complex hierarchy of laws and documents regarding spatial planning

Open spaces are essential to the quality of life and for the fulfilment of various economic, environmental, and social functions. The regional master plan encourages open space preservation and the development of new open spaces. One way to preserve open space is by increasing the development density in various plans and reshaping the urban design. Other ways were to adjust extension capacities and to establish limits to urban sprawl in some sensitive areas with urban fronts of regional interest. The objective is to protect agriculture, forests and natural areas which are important carbon sinks. The regional master plan supports their functional viability and the preservation and creation of ecological corridors.

Densification involves designing the city differently, with a closer connection to nature. Therefore, the regional master plan determines the need for green spaces, in the heart of the agglomeration, by prompting municipalities to strive towards an objective of 10 m^2 of green area per inhabitant and to define an agglomeration green grid consisting of localise green spaces as well as recreational areas of regional interest. The Plan reserve 2,300 ha of new parks and gardens and an agglomeration green grid. The regional master plan also spurs the protection and the reopening of the rivers in the urban areas. These urban open areas and water spaces contribute to limiting soil sealing, thereby reducing flood risk from runoffs, and offer cooling zones to fight heat island effects.

Urban planning and environment are closely linked in the regional master plan. The regulatory value of the regional master plan ensures that consistent public policies are incorporated into the local town planning documents, the regional mobility plan and other sectorial documents. A shared monitoring-assessment system of the regional master plan ensures consistent follow-up of developments and their impacts on climate change. The public authorities are then able to act if these effects differ from the expectations. Using adaptation strategies will complement mitigation strategies, which aim to directly reduce the amounts of greenhouse gases and to protect and develop systems that act as carbon sinks.

FLOODING RISK MANAGEMENT NEEDS A MULTI SECTORAL APPROACH

The Regional master plan will have long term effect. But currently, management of climate change impacts face huge and present challenges as the vulnerability of the Paris region increases due to urban expansion and on-going climate change effects, which are mainly heat waves, flooding and storms. Urban expansion extends the area of vulnerability, increases built surfaces thereby contributing to higher urban temperatures, and increases impervious surfaces which increase runoff into streams and rivers. Several floods in the last few years demonstrate this increase[1].

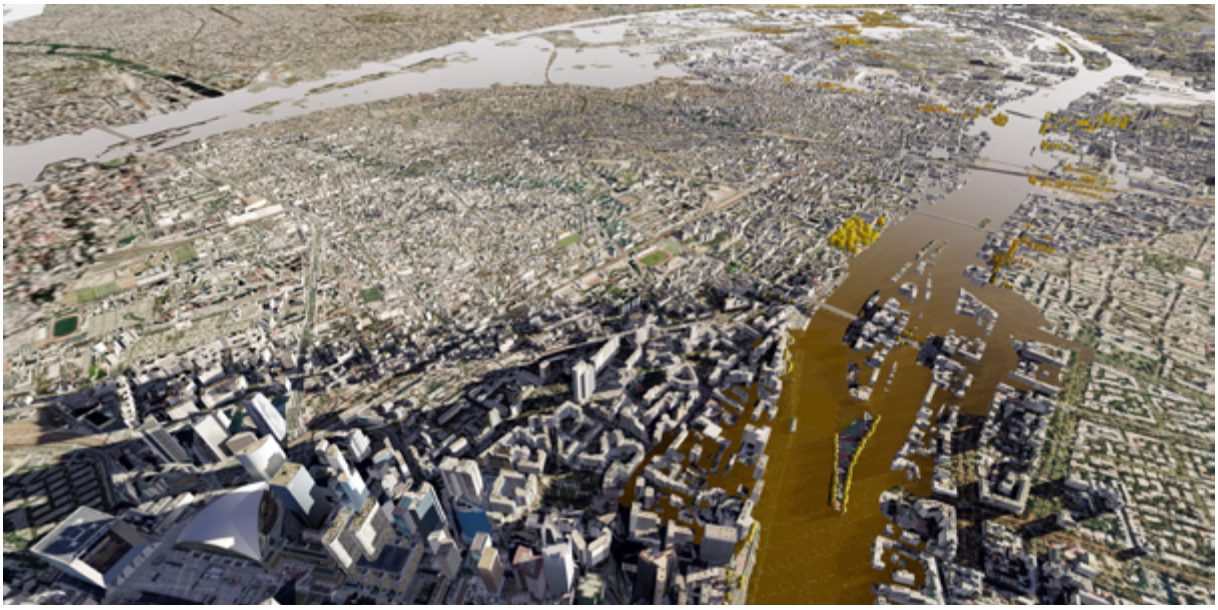

FIGURE 6: Flooding simulation and domino effect Paris's suburbs. SOURCE: Crue 3D

Flooding has emerged as a public safety and crisis management issue since the mid-2000s. The severe consequences of flooding on human settlements (435,000 homes and 830,000 exposed inhabitants are in flood plains) and socioeconomic assets (100,000 businesses and 750,000 jobs are located in flood plains) warrant the preparation of specific measures on risk management and prevention.

The effects of floods are numerous and cumulative. Tackling this issue requires a systematic approach considering the uncertainties and the domino effect on different urban networks, activities and urban services. These secondary impacts exceed the flooded areas and would influence the daily lives of millions of Parisians. The duration of the flood can reach several days to several weeks (cf. 2016 flood event) in the most affected areas, with consequences in terms of crisis management as well as the issues of the post-crisis. In fact, production and distribution of urban services (such as solid waste management, water treatment, sanitary and waste water treatment plant, large energy reservoirs, industrial factories and warehouses are organized around major structural facilities) are often located close to the rivers. The flooding of energy source posts and the medium voltage, together with emergency power disruptions, needed to protect the installations and facilitate their return to normal, has an impact on all the other networks and business sectors (water, telecommunications, transport, health, industry, etc.).

The metropolitan activities depend strongly on the mobility system. The main

FIGURE 7: Flooding event in Paris 2016.
SOURCE: S. Carrage/IAU îdF. Crue 2018 à Lagny (77)

public transport company RATP[2] revealed that in a hundred-year flood scenario, nearly 45% of its underground and mass transit train (RER) network would be stopped for several days to several weeks, with a significant impact on the several million daily trips. The national railway traffic would also be extremely disturbed at several major railway stations. Flood-related damage to the road networks would result in difficulties in obtaining supplies for the population, impact business logistics and even impact the organizations responsible for the management of the crisis and assistance. To secure main communication infrastructures is crucial for managing crisis.

In Ile-de-France, the normal operation of various regulatory instruments (civil security, safety of activities of vital importance, flood risk prevention plan…) are sectorial. During a crisis, when the domino effect spreads from one network to another, the continuity of operations relies largely on the management of the interdependencies between operators (energy, telecommunication, mobility, water, sewage). The extraordinary complexity of Paris region governance, with 8 districts, 1,276 municipalities, 64 "Territories", more than 700 intercommunal syndicates for public service delivery, and now a "Greater Paris metropolitan area" that covers only the core part of the agglomeration, makes coordination very difficult. The main challenge for resilience is then to find the way for managing these interdependencies, more than planning for crisis and post crisis management.

COOLING THE CITY

Recent climate records have shown a clear increase in the number, duration and intensity of heat waves in Ile-de-France region. By the end of the century, the region will probably experience an average of 11 days of excess heat per year. Urban heat islands are characterised by hotter air temperatures in central districts especially during the summer and at night. The shape of urban heat islands fluctuates according to the strength and reaction of dominant winds and warm breezes. During the night, air cools less quickly because of the heat released by materials in the form of infrared rays, which are trapped by the dense, compact surfaces of buildings. This heat releasing effect is primarily due to the presence of artificial surface materials, roughness length, scarcity of water and vegetation, and the presence of heat-emitting and polluting anthropological activity exacerbated by meteorological conditions.

Night time is a crucial period for organisms to recover from the effects of heat. However, during the 2003 heat wave the urban heat island reached a peak intensity of 8°C above the ambient temperature during the night, and double its usual intensity during the summer months. This had a direct negative effect on health and sanitary conditions. During this heat wave the Ile-de-France region had the highest overall increase in mortality in France.

The vulnerability of cities to the effects of summer heat waves affects the metropolitan ecosystem in terms of water resources, energy sourcing for air conditioning units, air quality, thermal comfort, alteration of natural elements, and the risk of degradation to buildings and infrastructures. The challenge of reducing vulnerability to heat waves is crucial when urban policies encourage increasing population density and the intensification of activities in current urban areas. Densely populated areas require specific solutions, such as the increased use of surfaces covered with vegetation, surfaces providing shade, the provision of water surfaces, the use of building materials with specially-adapted thermal and optical properties (albedo effect), the reduction of anthropogenic heat sources, and the morphology and configuration of various development zones, health services, district cooling, water management, etc.

Amongst the measures being considered, revegetation of the urban landscape constitutes one of the most efficient way to cool cities. Urban revegetation works in several ways: evapotranspiration; energy consumption due to the transformation of liquid water into vapour; and, the interception of a portion of the solar rays descending on the area by shading the ground and the surfaces of buildings. During the summer, these mechanisms contribute to the improvement of the urban microclimate. Revegetation of urban surfaces is a no-regret strategy.

Various options for revegetation exist: trees lining streets; grass or bush beds in roads and roundabouts; green belts around buildings; parks; undeveloped land; grassy ditches; agriculture and peri-urban forests, etc. Each option has distinct characteristics and therefore does not induce the same effects. Several scenarios have been tested at the Paris/Ile-de-France region scale (Muscade research project, Météo France model). In fact, all open-ground revegetation solutions are effective in terms of water runoff and the limitation of the effects of thermal stress felt by individuals at street level. The effect of revegetation strategies vary depending on the urban typology. Arboreal vegetation strategies are more effective especially in districts with multi-dwelling units. The cooling effect increases clearly with the rate of revegetation, to a maximum reduction of -2°C. Planted rooftops only appear to only produce benefits when they are irrigated, but with minimal results.

The cooling of the exterior microclimate, induced by revegetation, leads to a reduction in the use of air conditioning, and therefore of associated energy consumption. Without specific adaption, the consumption of energy used for air conditioning is very high. Non-irrigated planted rooftops can act as insulators, creating energy savings. Irrigation increases their evapotranspiration effect, leading to a three times reduction in final energy consumption. By regulating the exterior microclimate, revegetation strategies indirectly cause a reduction in the demand for air conditioning in buildings.

But the maximum reduction in energy consumption is brought by the synergetic effect of combining two revegetation strategies employing different physical mechanisms; cooling of the air at street level via arboreal revegetation in open ground in tandem with the insulating effects of roof gardens. Trees with higher mobilization of soil water and more ample foliage have a more effective means of managing ground water than herbaceous vegetation. Trees induce greater energy savings in terms of climate control with equal water consumption.

CONCLUSION - ESTABLISHING A GREEN AND BLUE GRID IS FUNDAMENTAL

The challenges of adaptation to climate change are intensified in cities. Generally, the answers adopted by cities are compactness and intensification to reduce mobility needs and greenhouse gas emissions. But densification increases the heat wave effect in the core part of the agglomeration and stress the ecosystem of the metropolis. Strong measures should then be adopted to reduce this vulnerability as it constitutes a major public health issue. In fact, climate change remediation modifies the hierarchy for actions in cities, setting greening (Green) and water resource management (Blue) as the top priorities.

FIGURE 8: Reintroducing Nature in the City.
SOURCE: C. Legenne/IAU îdF. ZAC Paris Rive Gauche, Jardins des Grands-Moulins - Abbé-Pierre; bassins à Paris (75)

Crisis management for flooding require more coordination between sectors because of the domino effect of affected urban services and activities, and its impact on the daily life of Parisians. This challenge requires a new governance model that is very difficult to implement in a metropolitan area like Paris/Ile-de-France region due to its extraordinary institutional complexity.

Crisis management for heat waves requires immediate measures mainly for fragile populations (the number of elderly in the Paris region is increasing). But cooling the city needs revegetation of urban areas while urban densification increases the price of the land and can reduce the green areas. The balance between densification and revegetation is a difficult challenge for urban policies that require support from different levels. Environment policies and legal framework should then be superimposed to urban planning.

The Regional master plan tackles the issue of climate change for the long term and tries to combine the intensification of the existing urban areas. It proposes mandatory regulation for densification on brownfields and around well-connected areas, and at the same time, defines the need to develop a green grid inside the core agglomeration with connections with the rural areas and ecological regional corridors. It also reduces the areas open for urbanization in flooding areas and encourage the opening of covered rivers.

In fact, climate change reposition some fundamental elements of urban planning to the top priority for planning cities. Green and blue grids are crucial elements to manage risks and cool cities and cannot be considered only as constraints for urbanization. Their implementation is the main condition to reshape cities facing climate change. The tools for reintroducing nature in the cities should be strengthened at all level of planning, from national/regional to local scales.

Climate change pressures stakeholders in metropolitan areas to find better governance between sectors and between territories to manage crisis and post-crisis. A resilient metropolitan management should be able to prevent, to alert, to manage crisis, and, to recover fast to normal level of activities and operation. It is mainly a question of coordination between sectors that are strongly linked in a metropolitan area.

Despite of large technical capacities for planning, analysing, and proposing solutions to the main climate change challenges facing the Paris/Ile-de-France Region, the major difficulties remain because of the institutional complexity of the metropolitan region. The low level of institutional integration at the regional level, which is the relevant scale for managing Paris/Ile-de-France metropolis, makes it difficult to implementation solutions to climate change impacts and to cool the city. Crisis events could be strong factors to trigger changes in the management of the system of actors, for the benefit of the population.

ENDNOTES

1 But they have never reach the highest level which occurred in 1910 when the Seine and the Marne rivers flooded Paris City

2 https://en.wikipedia.org/wiki/RATP_Group

REFERENCES

This article is mainly based on the following documents:

IAU, *Ile-de-France 2030 regional master plan*, Paris, 2013

IAU, Note rapide n° 662, *Revegetation Strategies helping urban areas combat the effects of heat waves,* Paris, 2014

IAU Note rapide, n°661, *Vulnerability of Towns and Cities to Rising Temperatures, assessed using the "Local Climate Zones"*, Paris, 2014

IAU Note rapide n° 660, *Sdrif: a territorial model to anticipate climate change*, Paris, 2014

IAU Note rapide n°682, *The urban resilience when faced with risks: the necessity for a collaborative approach,* Paris, 2015

3D video simulation Flooding Paris. Source : IAU îdF