DEFINITIONS – VARIABLES - EFFECTS

Urban Heat Islands (UHI), vulnerabilities and health effects, levers of action

I. Measurement of the "UHI" hazard (source: Elioth by Egis):

Temperature difference observed between an urban area and its less urbanized peripheral environment. More marked at night.

Exacerbated by **climate change** that multiplies the frequency, intensity and duration of heat wave episodes.

Materials (soil and buildings) and morphology of the city (configuration of the urban fabric through the density of buildings, the orientation, the width of the streets, roughness (obstacles that hinder the flow of air) => local changes in humidity, wind and air circulation, temperature (winds, especially thermal breezes, themselves have the effect of dissipating surface heat and regulating temperature). **Urban canyon** phenomenon in dense urban fabric, which prevents heat dissipation. **Urban boundary layer** = unstable, closed-loop atmospheric layer that takes the form of a heat dome blocking hot (and polluted) masses over the city. Role of thermal breezes in the formation of this dome.

Intermediate factors: **thermal capacity** and **thermal inertia** (the capacity of a material to accumulate and then return heat more or less quickly (with a time lag), linked to the massive properties of a material) and **albedo** (reflecting capacity of solar radiation, ratio between reflected flux and incident solar flux, related to the surface properties of a material), defined for a given material or at a higher spatial scale (a roof, a city, we speak of effective albedo). The canyon effect consists of **radiative trapping**.

Extent of mineralized surfaces, color of materials, waterproofing of soils, low vegetation (vegetated soils cool by evaporation) and low water presence, city uses (traffic, use of air conditioning, industries) have an effect on the overheating of the city.
Consequences: decreased comfort in the city, increased demand for air conditioning, increased pollution, health risks, excess mortality.

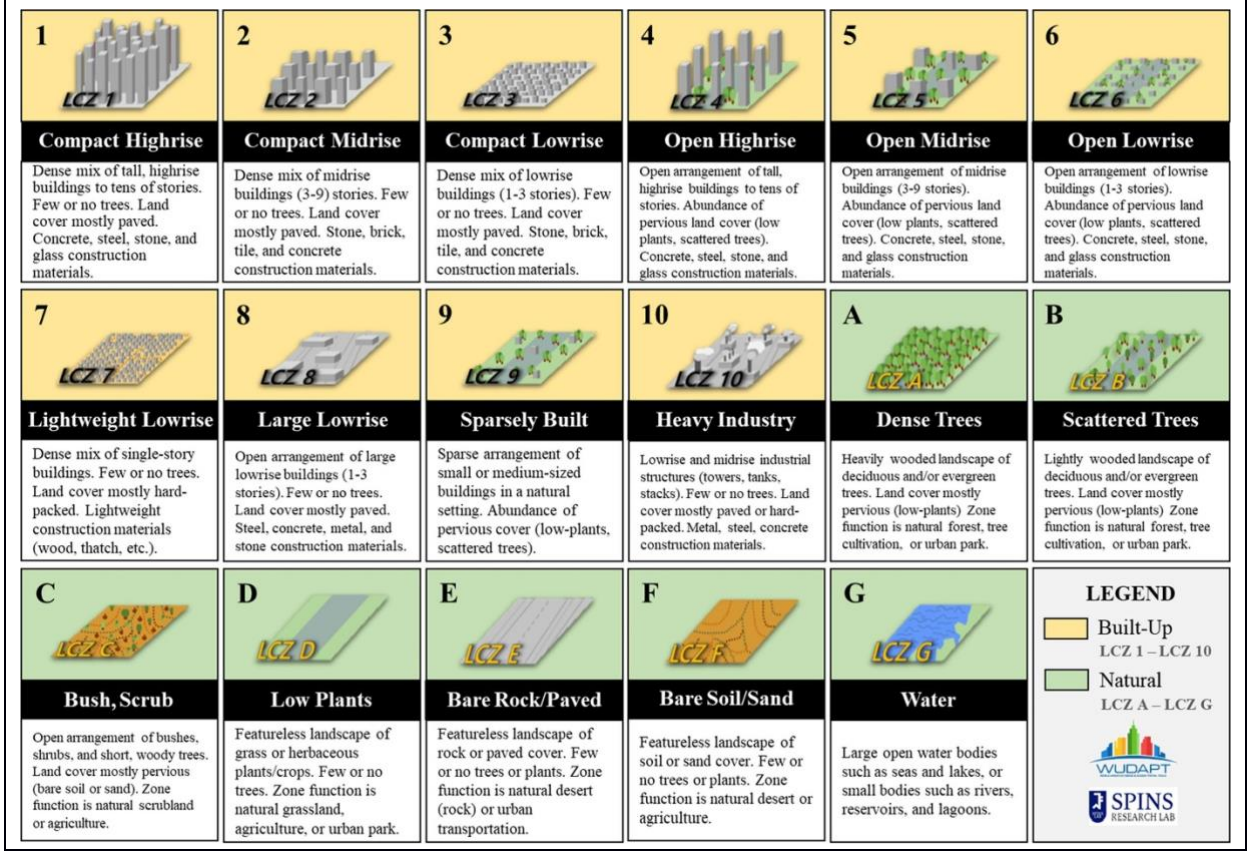
Modelling: **Urban model** (integrating vegetation data (including tree height), water, built volumes, surface characteristics) **=> Microclimatic model** (integrating weather data, with or without taking into account the local effects of winds) => **Thermal comfort model** (prediction of the thermal sensation of users, through the Universal Thermal Climate Index ; quantification of the number of hours per thermal sensation and comfort thresholds) => Simulation of scenarios to define **cooling islands**.

The purpose of cooling islands is to mitigate the effects of urban heat islands (UHI) and the associated health risks. Beyond that, they also have a positive effect on social interactions, healing, well-being, etc.

LCZ classification and diurnal/nocturnal UHI potential (Pascal *et al.*, Santé Publique France, 2020)

The LCZ (LOCAL CLIMATE ZONE CLASSIFICATION) classification was developed to provide a framework for the analysis of Urban Heat Islands (UHI) and urban climate, and to harmonize international research on these topics (Stewart and Oke 2012). The principle is to document, on a fine scale, several parameters that can modify the climate locally, then, to classify the possible

combinations into 10 types of «built» LCZ and 7 types of «natural» LCZ (a typology of LCZ is presented below). Each of these types is associated with a range of admittance (which expresses an ease of energy transfer), albedo (which expresses the reflective power), and anthropogenic heat production, which will favor or not the occurrence of a ICU. Measurement campaigns in different cities around the world have shown that on clear, calm nights, there is a growing temperature gradient from “natural” LCZs to “open” and “compact” LCZs (Stewart and Oke 2012).



II. The climatic vulnerabilities

Inhabitant vulnerabilities are at the meeting point of three dimensions, linked to the profiles of individuals, characteristics of the household and the place of life (housing, the building, its local environment), sources of **social inequalities in space** (Molina et al., 2023):

- **Exposure**: varies according to factors related to places and lifestyles of individuals
- The **sensitivity** of the organism, at the junction of many processes: thermophysiological, psychological, socio-spatial, cultural. Varies by individual and social group: age, health, physical condition, level of activity, personal history and previous exposures
- **Adaptive skills**, which refers to the ability to reduce the impact of damage sustained. They depend on:
    - Skills (physical, cognitive)
    - Resources (economic, cultural capital)
    - Competencies, related to three areas:
        - Knowledge of inhabitants,

- Know-how, which refers to the field of practices including socio-spatial practices and uses of places,
- Relational skills, family networks, interpersonal relationships.

Related concepts: "**tolerance thresholds**" (Molina and Allagnat 2019), and "**tolerance ranges**" (Quenault 2020): adaptive capacities are limited and evolving.

According to ISadOrA-Clé 14, EHESP-a'urba, 2020:
The main factors of vulnerability come from **age** (at both ends of life), **economic insecurity** (Besancenot, 2015), **habitat characteristics** (insulation, ventilation, etc.) and **lifestyle habits** (consumption, addiction). Certain pre-existing medical conditions (psychiatric, cardiovascular, neurological and mental disorders, etc.) should also be considered, as should pregnancy (Levy, 2016; Laaidi et al., 2014 ; Page et al., 2012). Homeless people (including migrants) should also be given special attention (Easac, 2019).

In epidemiology studies: use of a **deprivation index as** a general population geographic indicator of social disadvantage specifically adapted to health studies

See for example the European Deprivation Index using survey (EU-SILC) and census data aggregated to the smallest geographical unit available.

See also the **Swiss neighbourhood index of socioeconomicposition**

https://smw.ch/index.php/smw/article/view/3285

III. Health effects

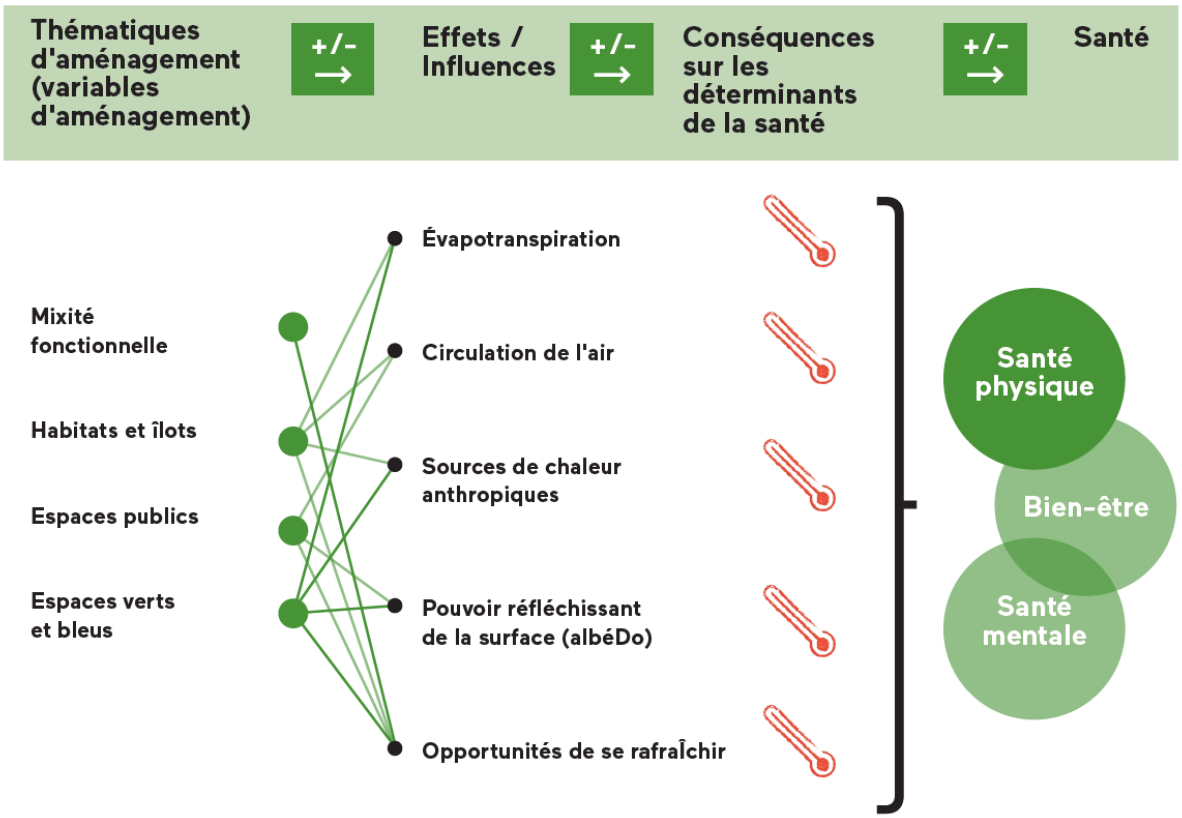
According to ISadOrA-Clé 14, EHESP-a'urba, 2020:

Regarding the **direct effects** of heat waves on health, in general, overheating affects the **cardiovascular system** and **respiratory system**. The effect of temperature rise would also have an impact on **mental health** (suicides, violence) (Burke et al., 2018; Easac, 2019). Other indirect effects have been shown such as effects on **sleep** or increased **violence and crime** (Easac, 2019). Thus, during heat waves, the phenomenon of UHI can cause great discomfort or even **excess mortality**, especially towards vulnerable people (Laaidi, 2012).

Heat waves increase **pollution** in different ways: increased emissions from primary sources when the weather is nice and hot, transformation by the sun and heat from primary pollutants into even more toxic secondary pollutants, ozone pollution, caused by solar radiation, stagnation of polluting particles in the lower layers of the atmosphere due to high pressures. However, it is well established that pollution **aggravates health problems** (including respiratory diseases).

IV. Levers for action

According to ISadOrA-Clé 14, EHESP-a'urba, 2020:



(source: ISadOrA, 2020)

Urban context

- **Functional diversity** : Location of sensitive institutions (including social housing, early childhood or elderly care institutions, schools, care and medico-social institutions) : close to green areas with trees so as to promote their **accessibility**, develop their surroundings in a logic of cooling island; ensure the internal thermal comfort of equipment (including those accessible free of charge) and sensitive establishments.

- **Housing and urban blocks** : layout of the building (height/distance ratio between buildings, opening to the sky («Sky View Factor SVF»), opening of the island on the summer prevailing winds or creation of a permeability of the building in case of implantation perpendicular to these winds), shape, size and design of open spaces, flooring, roofs, materials of facades, templates, colours, vegetation of the interface and free spaces; + quality of housing (thermal comfort, through character)

Public domain

- **Public spaces** : flooring (materials as porous as possible and light color), vegetation of public space, shading quality of the most frequented spaces and places of break, reinforcement of public transport, valorization of active modes of travel, mesh of green and soft ways, following a logic of shortcuts (continuity and connectivity of pathways)

Environmental context = climate + water + vegetation + soil

- **Green and blue infrastructure**: ecological engineering systems, size and type of blue spaces, types of plants and species, anticipation of the evolution of vegetation anticipation of the evolution of vegetation, shade quality and presence of water (stormwater management), identification of water and vegetation continuities

⇨ **Concept of "public environment"** (A'urba, 2020), **ecosystemic approach**: combines public space with the two forms of context that are intertwined, urban and environmental (a'urba, 2020): decompartmentalized and multi-scale approach, considering urban spaces as an integral part of an ecosystem. Think of the cooling island as a local declination of supra-communal strategies, as an integral part of strategies developing green and blue infrastructure: Water + soil + vegetation = three essential components to be taken into account in the development of cooling islands (optimal configuration = stormwater + open ground + three layers of vegetation, herbaceous, shrubby, tree). Requires a good knowledge of the urban subsurface, invested by different types of networks, pipes and heavy infrastructure such as underground car parks or certain foundations.

⇨ **Ecosystem services** provided by **arborization** and urban **revegetation**:
  - Reduction of heat islands by the energy consumed for evapotranspiration,
  - Improvement of air quality,
  - Promotion of health and well-being. Through the healing it provides, direct effect on the reduction of asthma, diabetes and high blood pressure, stress and mental health disorders.
  - Promotion of physical activity,
  - Reduction of energy consumption,
  - Reduction of flood risks, erosion control,
  - Improvement of ecological continuity and biodiversity,
  - Beautification, strengthening the attractiveness of the district: source of amenities

⇨ Make urban planners, management services (greenspaces, etc.) and territorial planning work together on climate change issues.

Schématisation de l'influence globale de la végétation sur les impacts sanitaires de la pollution de l'air et de la chaleur (Pascal 2019)