



Climate Proof Cities: Relevant Terms and Definitions

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Alphabetical list of key terms.

Short definitions with reference to the extensive definitions. Words in italics refer to other definitions in this list.

Acclimation

(Heat) Acclimation is defined as a method to acquire physiological adaptations to heat in an artificial environment (IUPS, 1987).

Acclimatisation

(Heat) Acclimatization describes the same process as (heat) acclimation, but happens in a natural environment. (<http://ksi.uconn.edu/prevention-strategies/heat-acclimatization/>).

Adaptation

In human systems, adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC, 2012).

Adaptation benefits

The avoided damage costs or the accrued benefits following the adoption and implementation of *adaptation* measures (IPCC, 2007).

Adaptation costs

Costs of planning, preparing for, facilitating, and implementing *adaptation* measures, including transition costs (IPCC, 2007).

Adaptation measures

Actual adjustments, or changes in decision environments, which might enhance resilience or reduce vulnerability to observed or expected changes in climate (United Kingdom Climate Impacts Programme, 2012).

Adaptation options

Descriptions of options (possible measures and actions) for climate adaptation (European Climate Adaptation Platform).

Adaptation Policy Framework

Is a structured process for developing adaptation strategies, policies, and measures to enhance and ensure human development in the face of climate change, including climate variability. The APF is designed to link climate change adaptation to sustainable development and other global environmental issues. It consists of five basic Components: scoping and designing an adaptation project, assessing current vulnerability, characterizing future climate risks, developing an adaptation strategy, and continuing the adaptation process (United Nations Development Programme, 2004).

Adaptation strategy

There is no agreed-upon definition of *strategy* that describes the field and limits its boundaries. One common contemporary definition describes it as being about maintaining a balance between ends,

ways, and means; about identifying objectives; and about the resources and methods available for meeting such objectives. This balance requires not only finding out how to achieve desired ends but also adjusting ends so that realistic ways can be found to meet them by available means (Freedman, 2013).

Adaptation Tipping Point

A moment for reconsidering an adaptation strategy not necessarily coinciding with a (“tipping”) change in the physical system, but possibly happening earlier due to slow changes in the physical system, at which predetermined thresholds are exceeded (Jeuken and te Linde, 2011).

Adaptive capacity

The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001). It includes the combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC, 2012). Adaptive capacity depends on threshold-, coping- and recovery capacity of the urban system. Adaptive capacity is one of three elements determining the *Vulnerability*.

Air temperature

See ‘Ambient temperature’

Albedo

The fraction of solar radiation reflected by a surface or object, often expressed as a percentage. Snow-covered surfaces have a high albedo, and vegetation-covered surfaces have a low albedo (IPCC, 2012).

Ambient temperature

The ambient temperature is a non-specific phrase used to describe the outside temperature. When taking the temperature with a thermometer, you are getting a general idea of the temperature of the surrounding air. Ambient temperature does not take into account the humidity or wind in the air (Oblack).

Anthropogenic heat emissions

The emission of heat caused by human activities (“anthropogenic heat”), including industry, households, buildings, transport, humans and livestock.

Approximated Wet Bulb Globe Temperature (AWBGT)

Thermal index of thermal comfort calculated with experimental relations based on air temperature, humidity and wind speed. Heat strain is experienced at AWBGT values larger than 27,5 °C.

Atmospheric temperature

See ‘Ambient temperature’

Building envelope (= building shell)

The area that separates conditioned space from unconditioned space or the outdoors. For example, walls and doors between an unheated garage and a living area are part of the building envelope; walls separating an unheated garage from the outside are not. The building envelope is the boundary separating the inside from the outside and through which heat is transferred. Areas that have no heating or cooling sources are considered to be outside the building envelope (Resource Center, 2009).

Catchment

An area that collects and drains rainwater (IPCC, 2007).

Computational Fluid Dynamics (CFD)

Computational Fluid Dynamics (CFD) is used to generate flow simulations (such as air flows through cities) with the help of computers. CFD involves the solution of the governing laws of fluid dynamics numerically. The complex set of partial differential equations are solved on in geometrical domain divided into small volumes, commonly known as a mesh (or grid).

(http://www.cfd-online.com/Wiki/Introduction_to_CFD)

Climate adaptation measures

See Adaptation measures.

Climate change

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2012).

Climate mitigation

See 'Mitigation' (of climate change).

Climate projection

A projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based upon simulations by climate models. Climate projections are distinguished from climate predictions in order to emphasize that climate projections depend upon the emission/ concentration/radiative-forcing scenario used, which are based on assumptions concerning, e.g., future socioeconomic and technological developments that may or may not be realized and are therefore subject to substantial uncertainty (IPCC, 2012).

Climate scenario

Plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. *Climate projections* often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate (IPCC, 2012).

Climate variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2012).

Cool roof

Roof that stays cool in the sun by strongly reflecting sunlight and maximizing thermal emission, roofs that have high solar reflectance (high *albedo*, or ability to reflect sunlight, spectrum 0.3 – 2.5 μm)

and high thermal emittance (high ability to emit thermal radiation, spectrum 4 – 80 μm) stay cool in the sun. The same is true of roofs with lower thermal emittance but exceptionally high solar reflectance (Akbari & Levinson, 2008).

Co-evolution

Co-evolution is the mutual adaptation through time without losing the own identity. Within the context of adaptation co-evolution is used to describe the challenge for professional spatial planners to try to co-evolve with the emerging practice of civic initiatives (Boonstra and Specht, forthcoming).

Cooling demand

Quantity of heat which – under standard conditions of usage – must be extracted from the rooms of a building during the cooling season in order to guarantee the preset inside temperature (Intelligent Energy Europe).

Cool wind corridor

An area connecting cool spots (e.g. parks, city hinterland) with urban hotspots to create advection of cool air aiming to reduce the temperature in these hotspots.

Coping capacity

The ability of people, organizations, and systems, using available skills, resources, and opportunities, to address, manage, and overcome adverse conditions (IPCC, 2012). The coping capacity is one of three elements defining the Adaptive capacity.

Coupling strategy (in Dutch: meekoppelen)

Long term strategy to implement adaptation measures during ‘windows of opportunity’, e.g. maintenance and retrofit works, and thereby reducing costs.

Cost-benefit analysis

Monetary measurement of all negative and positive impacts associated with a given action. Costs and benefits are compared in terms of their difference and/or ratio as an indicator of how a given investment or other policy effort pays off seen from the society’s point of view (Verbruggen, 2011).

Densification of cities

The increased use of space both horizontally and vertically within existing areas and new developments accompanied by an increased number of units and/or population (City of Cape Town, 2009).

Drought

A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. A period with an abnormal precipitation deficit is defined as a meteorological drought (IPCC, 2012).

Effectiveness of adaptation measures/strategies:

The capability of an adaptation measure/strategy to produce the desired result, which is generally expressed in meteorologically or hydrological variables. It might also be expressed in terms of human or man-made capital protected.

Cost effectiveness:

A measure of the extent to which the cost of resources, used to produce a specified output or outcome, has been minimized. Cost effectiveness involves comparisons of the costs of alternative ways of producing the same or very similar effect; or comparisons of the effect produced by

alternative ways with the same or very similar cost. An option is cost effective if it has the lowest cost of all the ways of producing the same or very similar effects. This does not mean that the option necessarily has a positive net benefit. (Productivity Commission, 2013).

Effective temperature (ET)

Index of thermal comfort, taking the organism's thermoregulatory capacity (warm and cold perception) into account. It is calculated with from air temperature, humidity and wind speed (Baranowska en Gabryl, 1981). ET is still in use in Germany; an adaptive form, named Normal Effective Temperature (NET) is routinely monitored by the Hong Kong Observatory.

Evapotranspiration

The combined process of evaporation from the Earth's surface and transpiration from vegetation (IPCC, 2012).

Exposure

The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected (IPCC, 2012). Exposure is one of three elements determining the *Vulnerability*.

Extreme weather event (Climate extreme)

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes' (IPCC, 2012).

Flood

The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (IPCC, 2012).

Pluvial flood: Pluvial' flooding is defined as flooding from rainfall generated overland flow before the runoff enters any watercourse or sewer. It is usually associated with high intensity events but can also occur with lower intensity rainfall where ground is saturated, developed or otherwise has low permeability resulting in overland flow and ponding in topographical depressions (Falconer, Smyth, & Maani, 2008).

Fluvial (river) flooding: Fluvial flooding occurs when the flow capacity of the watercourse is exceeded, causing water to spill from the river channel onto adjacent floodplain (Five Flooding).

Coastal flooding: Coastal flooding occurs when normally dry, low-lying land is flooded by sea water. The extent of coastal flooding is a function of the elevation inland flood waters penetrate which is controlled by the topography of the coastal land exposed to flooding (Ramsay, 2013).

Global warming

Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions of greenhouse gases (EEA, 2012).

Governance

There is a shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognizing the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of nongovernmental actors, and of civil society

(IPCC, 2012). Trends evolving in society therefore have a larger influence on the functioning of the government (Rydin, 2008).

Urban governance

Urban governance is a form of governance with a focus on the implementation of policies within a city. Urban governance is conceived as steering and coordinating urban policy, using the cooperation between public and private parties to achieve goals that have been determined together (Pierre, 2005).

Green (living) roof

Green roofs is a collective term which includes moss/sedum roofs, grass/herb roofs and is used for walkable planted roofs and sloping roofs. In principle two kinds of green roofs can be discerned: extensive green roofs and intensive green roofs. The difference lies in the intensity of the required care as well as the different way of constructing. Extensive green roofs are thinner and lighter in construction and generally less costly. Extensive green roofs are easier to realize on existing buildings. Intensive green roofs vary from watered grass/herb roofs to walkable city parks on buildings (Pötz & Bleuzé, 2012).

Hazard

The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012).

Heat flux

Heat flux or thermal flux is the rate of heat energy transfer through a given surface, per unit surface.

Heating demand

Quantity of heat which – under standard conditions of usage – must be fed into the rooms of a building during the heating season in order to maintain the preset inside temperature (Intelligent Energy Europe).

Heat strain

The adverse health effect because of heat stress (Berry, Mcneely, & Beauregard, 2012).

Heat stress

The presence of heat as stressor on the human physiology, resulting in an increase in temperature of the body. Heat stress in the strict sense is defined as 'the sum of the heat generated in the body (metabolic heat) plus the heat gained from the environment (environmental heat) minus the heat lost from the body to the environment, primarily through evaporation'. The degree of heat stress outdoors has been related to the Physiologically Equivalent Temperature scale (Daanen, Simons, & Janssen, 2010) & (Van Hove, Elbers, Jabobs, Heusinkveld, & Jans, 2011).

Heat wave

A period of abnormally hot weather (IPCC, 2012).

Humidity

Humidity is the amount of water vapor in the air. There are three main measurements of humidity: absolute, relative and specific. Absolute humidity is the water content of air. Relative humidity, expressed as a percent, measures the current absolute humidity relative to the maximum for that temperature. Specific humidity is a ratio of the water vapor content of the mixture to the total air content on a mass basis.

(climate change) Impact assessment

The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of climate change on natural and human systems (IPCC, 2007).

Impacts

Effects on natural and human systems of physical events, of disasters, and of climate change (IPCC, 2012).

Integrated assessment

An interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines so that all relevant aspects of a complex societal issue can be evaluated and considered for the benefit of decision-making (IPCC, 2007).

Land cover

Land cover is the discernible vegetation, geologic, hydrologic or anthropogenic features on the planet's land surface. These features, such as forests, urban area, croplands and sand dunes, can be measured and categorized using satellite imagery (Global Land Cover Facility).

Mainstreaming

Mainstreaming refers to the integration of adaptation objectives, strategies, policies, measures or operations such that they become part of existing policy domains (e.g. urban planning, water management, public health), processes and budgets at all levels and stages (UNDP, 2005).

Maladaptation

Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead (IPCC, 2001).

Mitigation (of climate change)

A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2012).

Multilevel governance

Non-hierarchical forms of policymaking, involving public authorities as well as private actors, who operate at different territorial levels, and who acknowledge their interdependence (Agency, 2012).

Natural climate buffers

Natural climate buffers are spatial solutions to climate impacts which are based on natural processes, and provide space for nature, as well as other social functions like living, working and recreation (Litjens, Herik, Winden, & Braakhekke, 2006).

No-regret adaptation options

Measures that turn out to be of benefit no matter how or if the predicted climate change impacts materialize (Kolmannskog, 2008).

Overheating hours

The number of hours that the operative temperature in a building is above the upper adjusted adaptive temperature limit. These temperature limits are calculated based on the neutral temperature, which is the temperature at which a human feels comfortable. The neutral temperature differs for each residential function, and is a function of the running mean outdoor

temperature. The running mean outdoor temperature is the weighted average of the outdoor temperature of the preceding days (Van Hooff et al, 2014).

Park Cool Island effect

The Park Cool Island (PCI) is an irregular pattern of cooler areas nested within generally warmer urban areas, created by shading and transpirational cooling and extended to the air above the non-vegetated areas through advective cooling (Chow et al. 2011)

PET (Physiological Equivalent Temperature)

A thermal comfort index (expressed in °C) based on the air temperature at which the human heat balance is maintained with core and skin temperatures equal to those under the conditions being assessed (Höppe, 1999). 'Standard calculations' are based on a man of 35 years old, with a length of 1.75 m and weight of 75 kg, standing in the sun, with a clothing factor 0.9 and with a heat production of 80 W.

Rainwater harvesting

Rainwater harvesting is an adaptation measures meant to store excess rainwater (in tanks or aquifers) and use it for low water quality application within the city (Hofman and Paalman, 2014).

Recovery capacity

The capacity of a society to recover to the same or an equivalent state as before a disaster. It is the capacity of a flooded area to reconstruct buildings, infrastructure and dikes (Van de Ven, et al., 2010). The recovery capacity is one of three elements defining the *Adaptive capacity*.

Recovery time

Within the context of water management, the recovery time is the time needed to empty the water storage unit before it can be used again for the next precipitation event.

Resilience

The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012).

Risk (climate- related)

Is the result of the interaction of physically defined hazards with the properties of the exposed systems – i.e., their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences – i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (United Nations Development Programme, 2004).

Run-off

That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water (IPCC, 2012).

Surface runoff

The water that travels over the land surface to the nearest surface stream (IPCC, 2007).

Scintillometer

A scintillometer is a device used to measure small fluctuations of the refractive index of air caused by variations in temperature, humidity, and pressure. It consists of an optical or radio wave transmitter and a receiver at both ends of an atmospheric propagation path. The receiver detects

and evaluates the intensity fluctuations of the transmitted signal, called scintillation. Scintillometers also allow measurements of the transfer of heat between the Earth's surface and the air above, called the sensible heat flux (Moene et al., 2004).

Sensitivity

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or climate change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2007). Sensitivity is one of three elements determining the *Vulnerability*.

Sky View Factor

The sky-view factor is a parameter defined by the part of the visible sky above a certain observation point as seen from a two-dimensional representation. The SVF ranges between 0 and 1. Values close to 1 mean that almost the entire hemisphere is visible, which is the case in exposed features (planes and peaks), while values close to 0 are present in deep sinks and lower parts of deep valleys from where almost no sky is visible (Zakšek et al., 2011).

Surface temperature

The Land Surface Temperature (LST) is the radiative skin temperature of land surface. LST is determined by the land surface energy balance and varies rapidly because of the low thermal inertia of the land surface (<http://land.copernicus.eu/global/products/lst>).

Synergy of adaptation and mitigation

The interaction of adaptation and mitigation so that their combined effect is greater than the sum of their effects if implemented separately (IPCC, 2007).

Thermal comfort

That condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ASHRAE, 2013).

Threshold

The level of magnitude of a system process at which sudden or rapid change occurs. A point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels (IPCC, 2007).

Threshold capacity

The ability of a society to build up a threshold against variation in order to prevent damage (Van de Ven, et al., 2010). The threshold capacity is one of three elements defining the *Adaptive capacity*.

Universal Thermal Climate Index (UTCI)

The UTCI is expressed as an equivalent ambient temperature of a reference environment providing the same physiological response of a reference person as the actual environment. UTCI was developed conceptually as an *Equivalent Temperature* (ET). Thus, for any combination of air temperature, wind, radiation, and humidity, UTCI is defined as the air temperature in the reference condition which would elicit the same dynamic response of the physiological model.

Both, meteorological and non-meteorological (metabolic rate and thermal resistance of clothing) reference conditions were defined:

- a wind speed (v_a) of 0.5 m/s at 10 m height (approximately 0.3 m/s in 1.1 m),
- a mean radiant temperature (T_{mrt}) equal to air temperature and,
- vapor pressure (v_p) that represent relative humidity of 50%; at high air temperatures (>29°C) the reference humidity was taken constant at 20 hPa.

- a representative activity to be that of a person walking with a speed of 4 km/h (1.1 m/s). This provides a metabolic rate of 2.3 MET (135 W.m⁻²) (Blazejczyk, et al., 2010).

Urban Boundary Layer

The Urban Boundary is situated directly above the Urban Canopy and is a local or mesoscale concept referring to that portion of the planetary boundary layer whose characteristics are affected by the presence of an urban area at its lower boundary. The modified layer is conceived to develop as an advective internal boundary layer. (Oke 1976)

Urban Canopy Layer

The urban canopy is a microscale concept, consisting of the air contained between the urban roughness elements (mainly buildings). Its climate is being dominated by the nature of the immediate surroundings (especially site materials and geometry). (Oke, 1976)

Urban canyon (or street canyon)

An urban canyon is a place where the street is flanked by buildings on both sides creating a canyon-like environment. Ideally an urban canyon is a relatively narrow street with tall, continuous buildings on both sides of the road. But now the term street canyon is used more broadly and the geometrical details of the street canyon are used to categorize them. The most important geometrical detail about a street canyon is the ratio of the canyon height (H) to canyon width (W), H/W, which is defined as the aspect ratio.

Urban climate

Any set of climatic conditions that prevails in a large metropolitan area and that differs from the climate of its rural surroundings (Encyclopedia Britannica, 2013).

Urban Heat Island (UHI)

The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on. (IPCC, 2012)

Surface Urban Heat Island (sUHI)

The difference in surface temperatures between the city and the surrounding countryside.

Atmospheric UHI

The difference in air temperatures between the city and the surrounding countryside. The atmospheric UHI can be divided in:

- o UHI of the atmospheric boundary layer above the city ('Urban Boundary Layer UHI') which depends on the geographical location of the city, its general configuration and morphology.
- o UHI at street level ('Urban Canopy Layer UHI'), where the presence of buildings, roads, trees and water has a direct and measurable effect on the microclimate. Discussions on the urban climate generally refer to this last effect.

Urban (thermal) plume

An urban thermal plume describes rising air in the lower altitudes of the Earth's atmosphere caused by urban areas being warmer than surrounding areas. Or phrased in another way: The Urban Boundary Layer is conceived to develop as an advective internal boundary layer. In the downwind region this layer may become separated from the surface as a new rural boundary layer develops underneath, and this has been termed the urban plume (Clarke, 1969).

Vulnerability

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is the function of the climate change hazard, the degree of exposure, its sensitivity, and its adaptive capacity (IPCC, 2007).

Weather Research and Forecasting (WRF) Model

The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs (<http://www.wrf-model.org/index.php>).

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