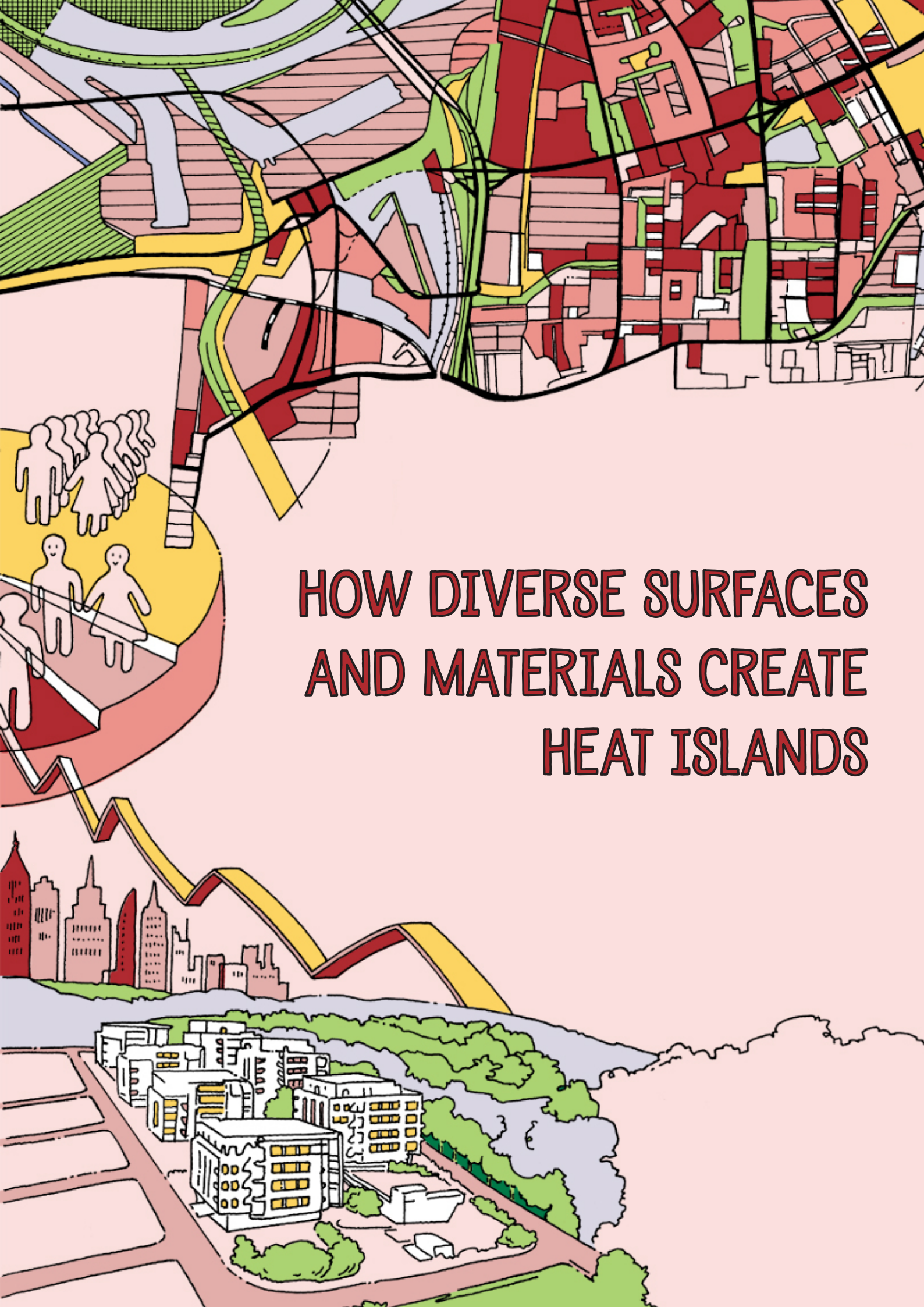


HOW DIVERSE SURFACES AND MATERIALS CREATE HEAT ISLANDS

INTRODUCTION

This indicator book was created as part of the Teaching Green project and should support teachers of students aged 10 – 16 years who are implementing education about climate change.

The educational process is divided into 4 steps. The first step is the creation of a group of students who will implement the project activities. In the introductory part, students fill out also a questionnaire about their attitudes linked to the indicator mentioned below. The second step is theoretical preparation. You can use online learning models or your own resources. The third step consists of practical monitoring of the indicator (at least twice). The result of the monitoring is a presentation prepared by the students containing findings from the practical part. In the final fourth part, students fill out the attitudes questionnaire again and the changes in their character qualities are evaluated.

CLIMATE CHANGE IMPACT

Measuring the temperature of green spaces/build-up spaces of city/countryside/park during hot days, comparison of temperature differences and their causes. Sharing the results of the activity (e.g. the temperature measured on different urban surfaces) and comparing them with the results of other schools of the same country or foreigner countries.

INDICATOR: Hotter temperatures of global surface

Project activities support development of 6 essential character qualities:

- **mindfulness**
- **curiosity**
- **courage**
- **leadership**
- **resilience**
- **ethics**

You can find these icons next to the exercises.

Mindfulness
wisdom, self-awareness, observation, insight
"The awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experiences moment by moment."

Curiosity
open-mindedness, exploration, passion, initiative, enthusiasm
"The essential desire for information, the drive to resolve uncertainty."

Courage
bravery, determination, confidence, risk taking
"The ability to act despite fear or uncertainty, in risky situations or when we are feeling vulnerable."

Leadership
responsibility, accountability, dependability, reliability, selflessness
"The relational and ethical process of people attempting to accomplish positive change."

Resilience
perseverance, grit, tenacity, resourcefulness, self-discipline
"The ability or set of qualities that allow one to overcome obstacles."

Ethics
benevolence, humaneness, integrity, respect, justice, fairness
"The moral principles that govern a person's behavior or the conducting of an activity."

Before you start, let students fill out the questionnaire about their attitudes!

THEORETICAL PART

Introduction to students

The air temperature in the urban environment is generally warmer than in the pre-existing surrounding natural areas, during the day and night.

The phenomenon is defined by the term **Urban Heat Island (UHI)** and is measured by the difference between air temperature in urban areas and the temperature in surrounding rural areas. This effect contributes to global warming mainly caused by greenhouse gas emissions of anthropogenic activities. Urban warming happens due to the greater absorption of heat during the daytime and slower release of heat at night by **artificial surfaces** like **paved roads** and **buildings.** Additionally, other characteristics like **albedo,** the fraction of solar radiation that is reflected towards the sky, affect the urban microclimate. Dark surfaces have lower albedo, therefore they absorb more radiation due to their low reflectivity and are warmer than bright surfaces. Therefore, dark and impervious surfaces can reach higher temperatures than permeable surfaces (asphalt can be more than 20° C warmer than lawns during a hot sunny day), thus significantly affecting local microclimates. UHI is particularly intense in big cities, under clear sky conditions, and in weak ventilation. In some specific cases, the difference can reach 9°C. The presence of green spaces in the urban environment can mitigate this effect. In fact, evapotranspiration by plants and shadow by trees can reduce air and surface temperatures.

I. Provide some examples of these climate differences in cities.
Point out the behaviour of people during hot sunny days to combat UHI effects such as looking for shade when parking the car, sitting on a bench or walking from shadow to another.

II. In the practical part Identify hot and cool spots in the school and measure temperature differences

III. Explain the reasons for the choice of this indicator: temperature can vary from spot to spot even at short distances and how the urban space is designed matters.

Before starting the investigation, students are asked a question about the different climate of the area/city where they live and other areas/city they know.

This might raise their curiosity and awareness about the fact that some areas in the same region have different climates (e.g. plains, mountains, countryside, forests, and the city) depending on many factors: environmental ones (latitude, altitude, presence of bodies of water like lakes, rivers, sea), and even within the city (park area vs concrete square).

? Questions for students

- **Can you describe the climate characteristics of the area where you live (within the same city or region)?**
- **Do you know other areas that have a different climate than the one you described?**
- **Do you think about why its so?**
- **Did you know that during summer, the city is warmer than the countryside? Do you wonder why?**
- **Can you indicate a cool spot (a place where you would like to stay during hot days) and a hot spot (a place you would avoid to stay during hot days) in your town? Can you describe why you choose them and which are the causes of such a difference between these places?**


SUPER
1
RIP
T+D=VL

RESOURCES FOR FURTHER STUDING:

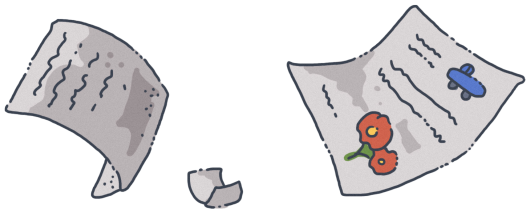
- MODULE 1
- MODULE X
- NASA | Urban Heat Islands - YouTube
- Climate Interactive

NECESSARY TOOLS:

- A gridded map (e.g. image from google map divided in a grid, figure 1) of an area selected by the students near the school or in town (e.g. a square or a park).
- One thermometer and/or Infrared thermometer to measure temperature of different types of surface.
- A worksheet file to record data *(Template surface temperature.xls)* or a free app for collecting georeferenced data *(e.g. https://five.epicollect.net/)*.
  See presentation on how to create your own Epicollect project in "Building an APP for data collection" in the repository.

Mention only what is necessary to support students efforts to search for data, others will be available in the module for teachers.

PRACTICAL PART



Aims of the activity

Measure the **differences in temperature** above **different types of surfaces** (grass, concrete, asphalt, water courses, coastal areas,...) and **different urban forms,** characteristics of the built environment, such as a street canyon, concrete or green square, park, near a river, trees on a street, or near a bike lane...). Track the differences during the day. Be aware of the factors of the environment around us that affect climate and why. Make an evaluation of the quality of the microclimate in the selected area and propose improvements to improve it.

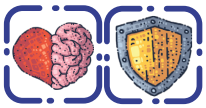
Orientation or Engagement

After finishing the theoretical part, during a hot day in spring or early autumn, go around the school area or your town and try to identify which are hot and cool places there?

Describe their characteristics and ***think:***

- **What are the reasons (main environmental variables) that affect temperature in these places?**
- **According to you, which are the surfaces that are warmer or cooler in the place you live on a hot summer day or night? Have you ever wondered why?**

? Questions for students



- **Among these places, which do you prefer and why?**
- **Do you notice negative or positive effects on the environment (plants, animals, human health) of the climates in those places?**
- **Did you experience a *very unpleasant* heat related situation during a summer day? Describe the situation around you. How did you react?**
- **Do you remember a situation where you could not sleep because of the excessive hot temperature during the night. Which are the reasons according to you? Do you remember your feelings in that situation?**
- **Due to climate change and the likely increase of temperature, what measures or actions could be implemented to mitigate increasing temperatures and unpleasant situations? (try to reduce activities that contribute to global warming, like greenhouse gas emissions and at planning level design urban spaces to mitigate UHI).**

Conceptualization

Discussion on the topic should lead to understanding of the factors that affect air temperature in general and its increase at the global and urban level.

Students are invited to apply these reflections at the level of their town or neighbourhood, for example, working on the places they think are characterised by high temperatures and identifying what can be the cause of such high temperatures.

The result should be the interest of pupils to find out and assess air temperature differences between urban and rural areas or in different parts of the town and understand how temperature is influenced by the urban surface typologies.

Let students work in groups and compare their findings and thoughts.

Working in groups, they have to ***think*** about the points below:

- **e.g. mark which areas you think are hotter or colder areas in town or near the school (during hot days in summer) on the map and describe them from the architectural point of view. Assess the surfaces and soil cover and take some photos of them.**
- **e.g. on the map, mark a place in town and in the countryside that has a weather station which provides data for free, and investigate how large the difference in temperature can be.**

The reflection deals with the equitable distribution of sites that are characterised by cooler temperature in the place they live.

Investigation

1. Select an area near the school (e.g. figure 1).
2. Download a satellite image of the area from Internet (e.g. Google Earth or other).

You can use an image of the same place during different years (e.g. using history tools in Google Earth) and look for differences in the landscape by comparing the images.

3. Classify the type of surfaces in the selected map and indicate if they are shaded by trees or not.

Help yourself by drawing a grid on the image (see *figure 1*). Choose grid cell size according to the precision you want to get (the smaller the cell the higher the precision). Count the grids for each type of surface on the image and try to make an evaluation of its quality.

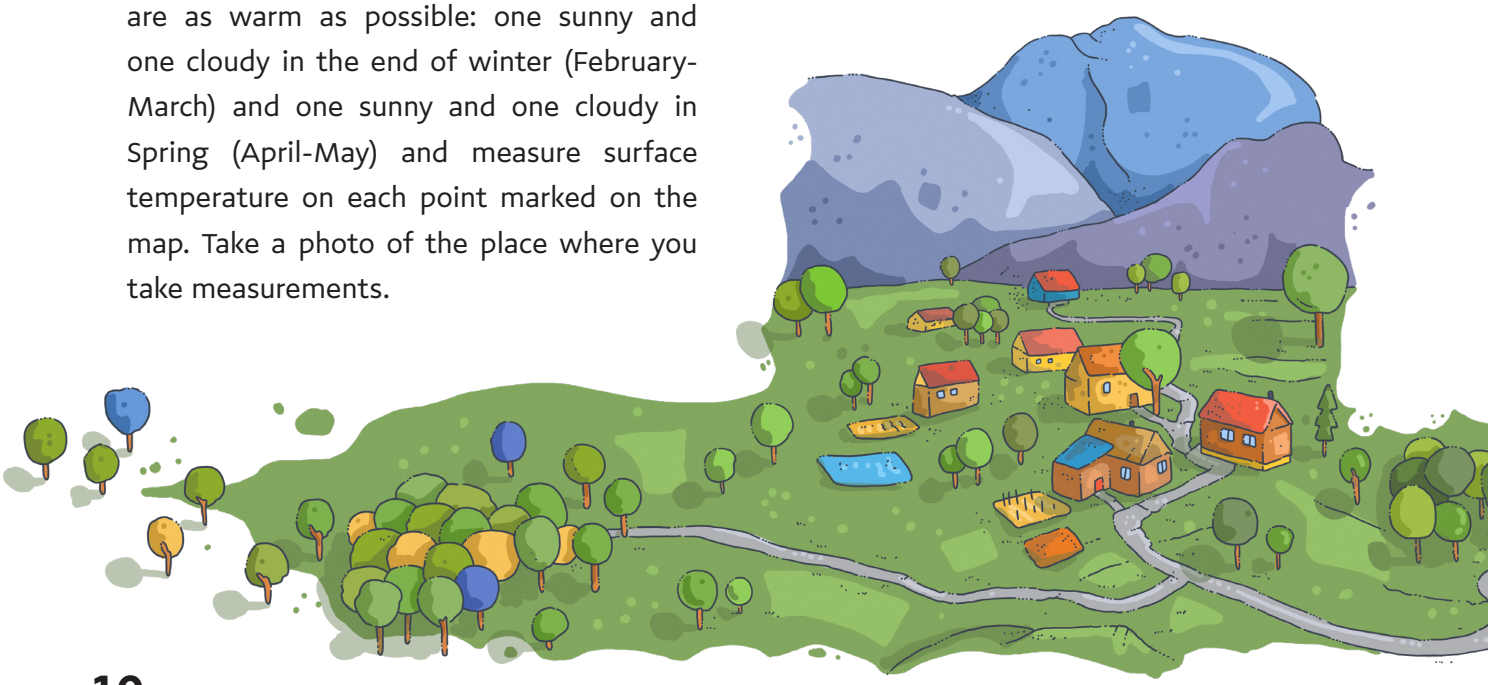
4. Compare it with historical images. E.g. Has the number of concrete surfaces increased or decreased?
5. Select different types of surfaces (e.g. asphalt, grass, soil, plastic) with different shading or in different urban geometry (e.g. roads with or without trees, paved square, garden). Mark the places where you are going to take measurements on the map (e.g A & B in figure 1).
6. Go outside during at least four days which are as warm as possible: one sunny and one cloudy in the end of winter (February-March) and one sunny and one cloudy in Spring (April-May) and measure surface temperature on each point marked on the map. Take a photo of the place where you take measurements.

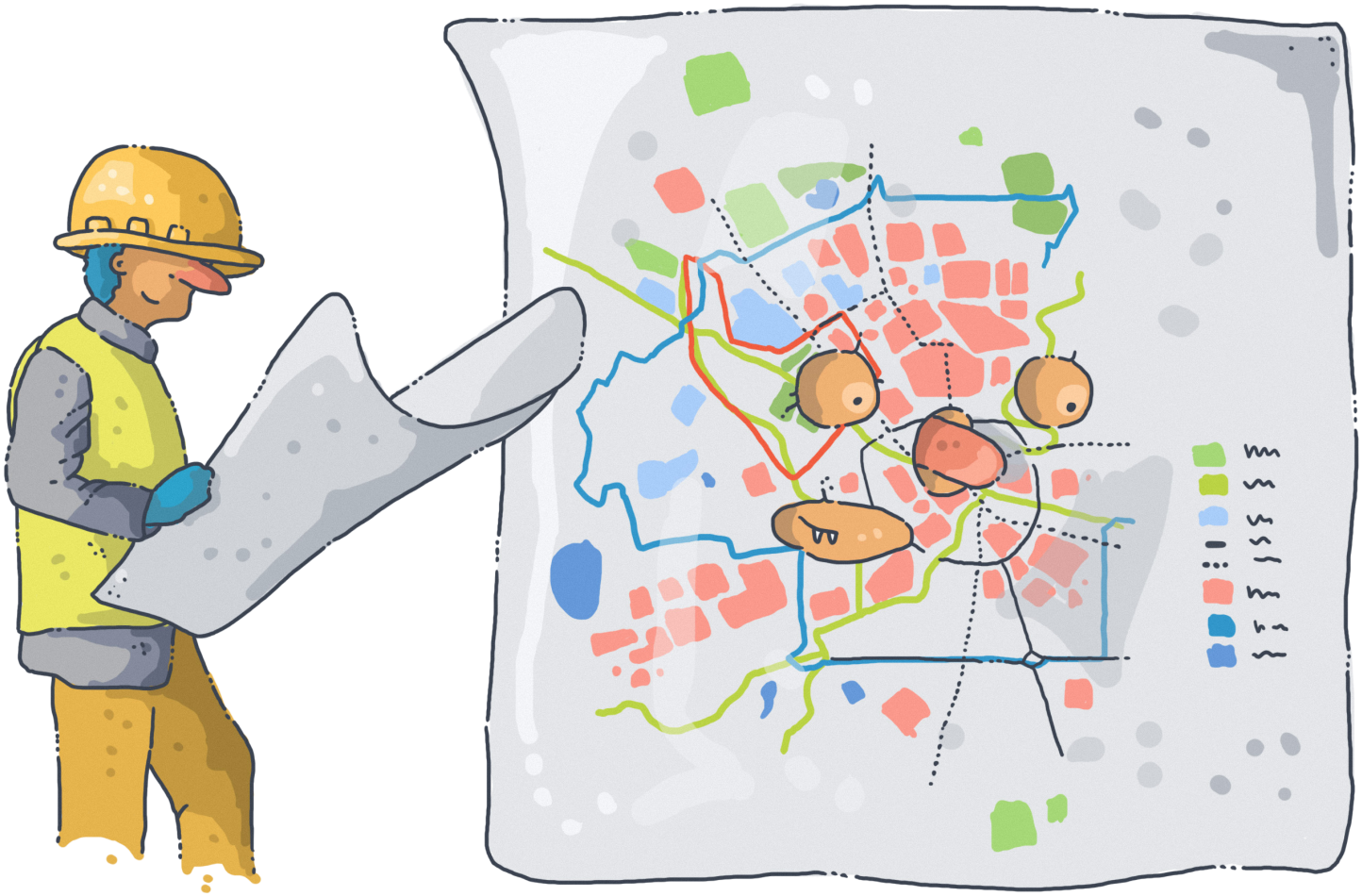
You can use a low-cost infrared thermometer to measure surface temperature (like those used to measure skin temperature) that gives a faster and accurate measurement. Otherwise, you can use a manual thermometer in contact with the ground, shielded from direct solar radiation but the measurement takes a long time (at least 5 minutes) and is less accurate.

Ask the students to read and record data at the same time of the day (e.g. midday). Take a note of: date, time, code of the site on the map, type of surface, surface temperature, air temperature (if you have a manual thermometer record it during the measurement otherwise look for the temperature on the local meteo service), and sky conditions during the measurement.

Use the **worksheet** of table 1 and 2 to record this data. Alternatively, you can create your own project in Epicollect (See presentation on how to create it in "Building an APP for data collection" in the repository) with the same information and record the data in the app. Then you can download data in a spreadsheet file.

Analyse data: for instance, calculate the average temperature of the whole area as a measurement of the quality of the urban space.





Do you think it is good or bad? Why? How would you improve it?.

Do this activity in different weather conditions (sunny or cloudy).

Observe the difference between the surfaces during good (clear sky) and bad (cloudy or rainy) weather conditions and in different seasons.

Conclusion

Create a report (ppt, video, article) which presents info about the sites, their characteristics, temperature, and differences between sites, trying to explain these differences linked to site characteristics.

From the results, students think about possible solutions to help out with reduction of temperature especially in hot climate conditions (e.g. suggesting different urban planning by increasing green areas and shaded area, trees, and water bodies such as fountains, ponds, rivers, or changing behaviour to reduce greenhouse gas emission).

? Questions for students

- **What can be done to mitigate the climate of outdoor spaces and improve the use of outdoors spaces? (e.g. outdoors activities, playgrounds etc.) and also stimulate green transportation (e.g. green corridors may stimulate walking or biking), improving the quality of life inside houses, reducing the need of air conditioning.**

ACTIVE PART

Students think about the school area or a neighbouring place and design a way to mitigate temperature in some areas outside the school e.g. increasing the shade. They explain the project and the motivation to the school director and try to implement it.

Define a challenge

Reduce greenhouse gas emissions by walking and cycling a distance and calculate how much GHG were saved.

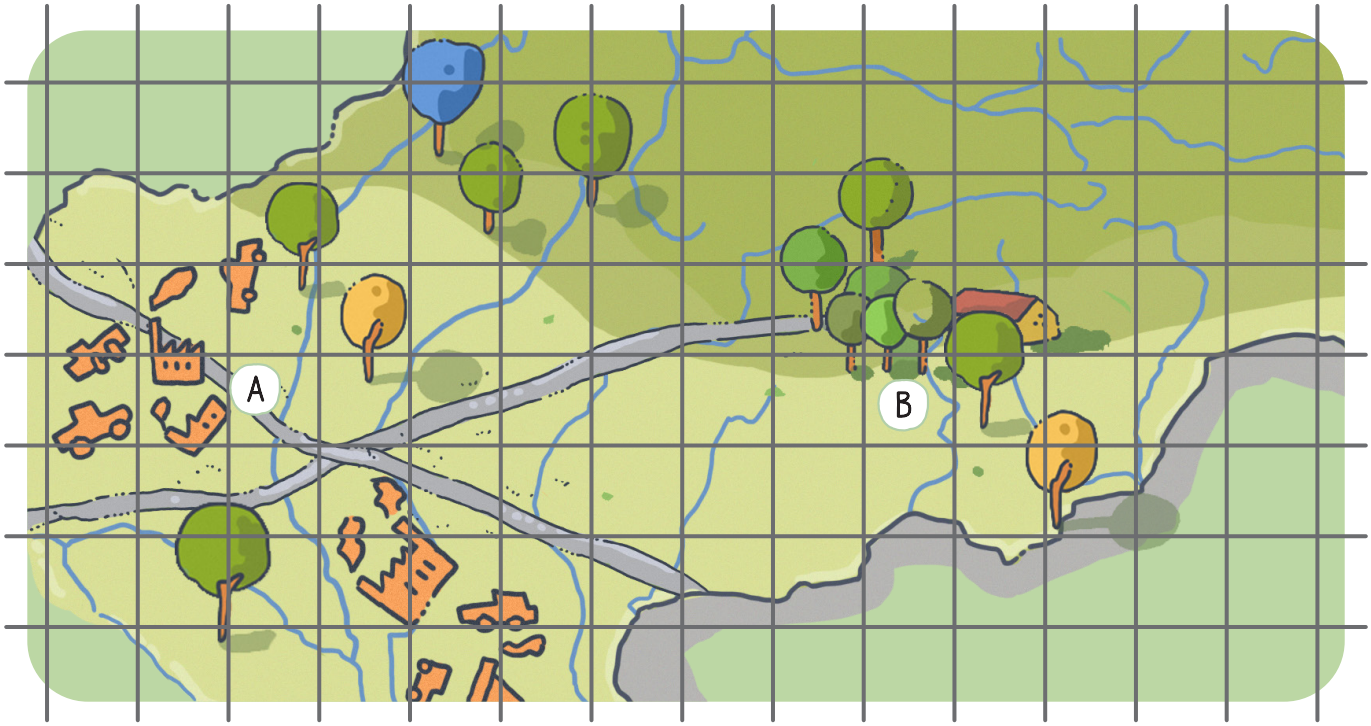
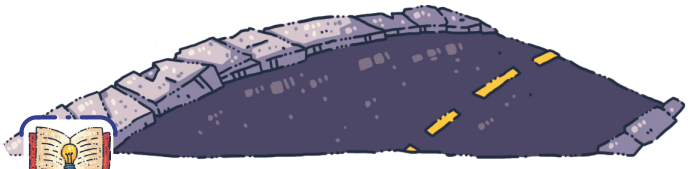


Figure 1 - Gridded photo of an urban area taken by google map (you can choose your own grid cell size) with markers (A, B) indicating selected points for measurements.

DATE	TIME	CODE IN THE MAP	TYPE OF SURFACE	SHADING (Y/N)	SURFACE TEMPERATURE (°C)	AIR TEMPERATURE (°C)	SKY CONDITIONS
05/07/2022	12:00	A	GRASS	N	40°	30°	CLEAR SKY
05/07/2022	12:05	B	ASPHALT	N	60°	30°	CLEAR SKY

Table 1 – Example of data collection with spreadsheet for collecting data on surface temperature. Use *table 2* for collecting actual data.



Surface types (e.g.):

- *Asphalt*
- *Grass*
- *Bare soil*
- *Concrete*
- *Synthetic*
- ...

Sky condition:

- *Clear sky*
- *Partly cloudy*
- *Cloudy*
- *Overcast*
- *Rainy*
- ...

Table 2 – Spreadsheet for collecting data on surface temperature.

SCHOOL NAME:	CITY (NATION):
CLASSROOM:	GROUP NAME:

DATE	TIME	CODE IN THE MAP	TYPE OF SURFACE	SHADING (Y/N)	SURFACE TEMPERATURE (°C)	AIR TEMPERATURE (°C)	SKY CONDITIONS

RESOURCES

NASA Urban Heat Islands. Available at: <https://www.youtube.com/watch?v=lnBO4vX82Fs>

The En-ROADS Climate Solutions Simulator. Avaliable at:

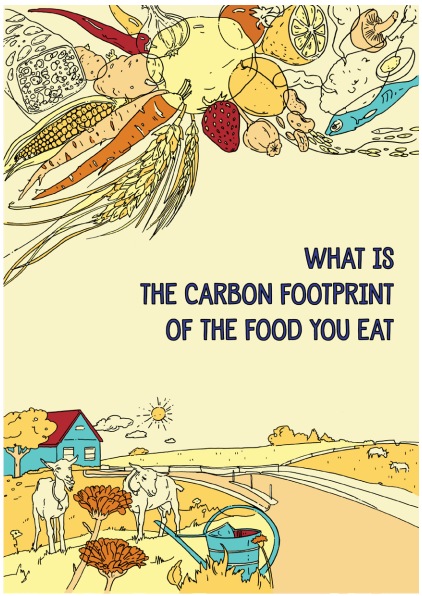
<https://en-roads.climateinteractive.org/scenario.html?v=22.5.1>.

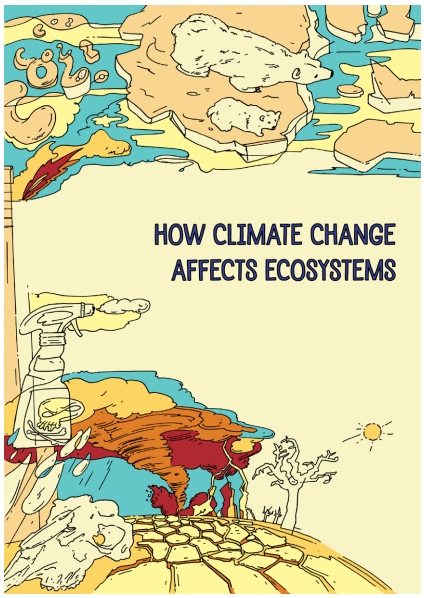
A worksheet file to record data. Avaliable at: <https://five.epicollect.net/>.

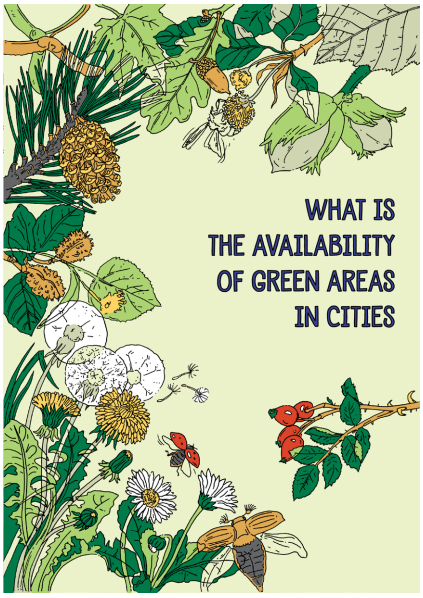
HOW DIVERSE SURFACES AND MATERIALS CREATE HEAT ISLANDS
Text: Luciano Massetti, Francesca Ugolini
Ilustrations: Tomáš Cíger, Katka Slaninková
Graphic Design: Andrea Plulíková
Publisher: Strom života (Tree of Life), Jelenia 7, 811 05 Bratislava, Slovakia
16 pages • Format: A4
Year of publication: 2023, 1st edition • **ISBN** 9788082930010

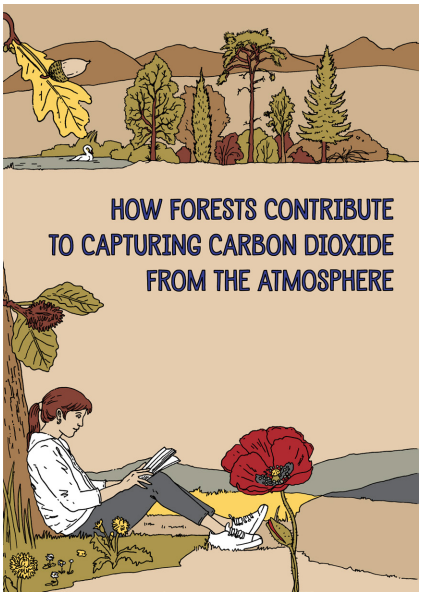
Creation of the this book was funded by the European Union – NextGenerationEU. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Commission. Neither the European Union nor the European Commission can be held responsible for them.

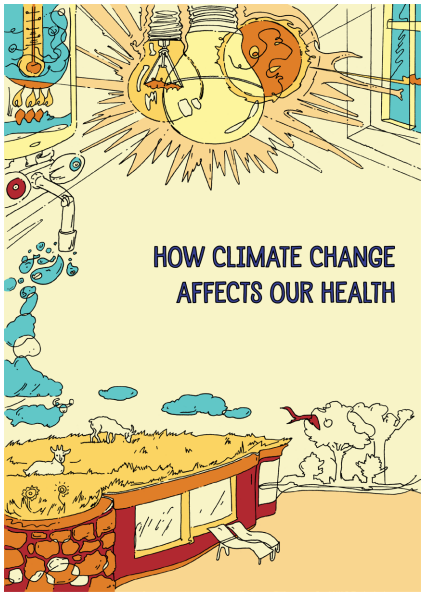
OTHER INDICATOR´S BOOKS YOU MAY LIKE CAN BE FOUND ON: TEACHINGGREEN.EU

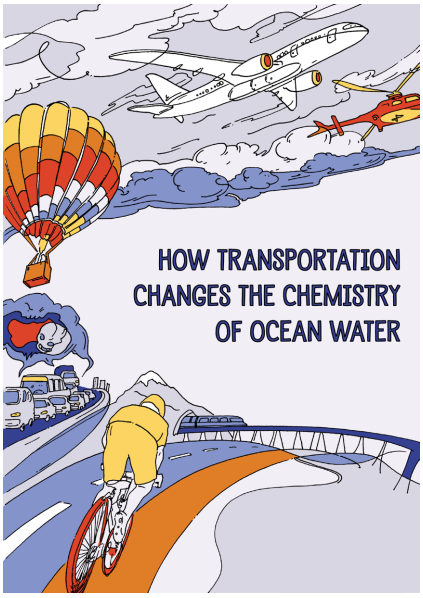


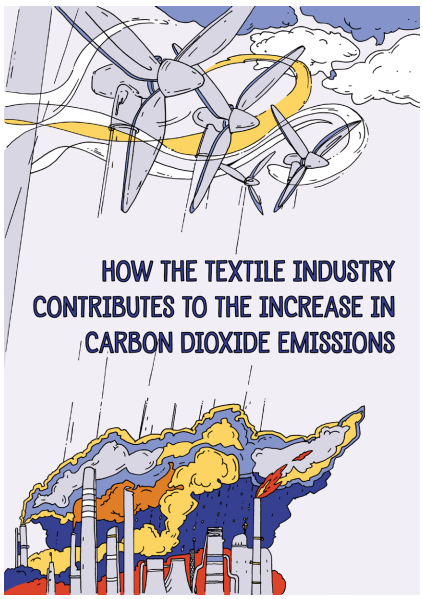


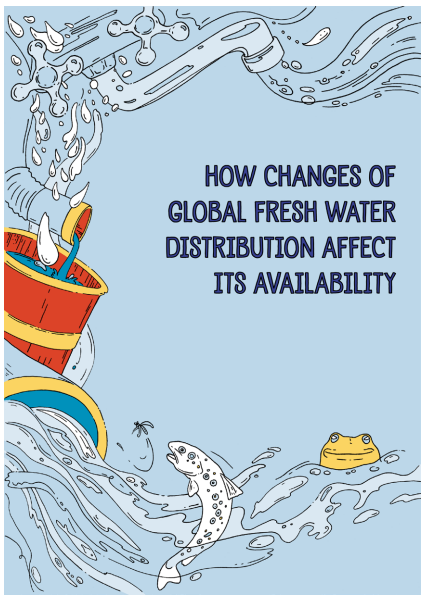












STROM ŽIVOTA

UNIVERZITA KONŠTANTÍNA FILOZOFA V NITRE

National Research Council of Italy
Institute of BioEconomy
Department of Biology, Agriculture and Food Science

CARDET

Co-funded by the European Union

TEACHING GREEN

TEACHING GREEN - From Climate Change Education and Awarenes to Citizen Science Action
Contract Number: 2021-1-SK01-KA220-SCH-000032754
teachinggreen.eu

9 788082 920010