Educational Toolkit

Age: Grade 3-9 (9-15 years old)

Topics: Hands-on activities, Light pollution education, exploration, night sky assessment, digital tools, environmental awareness, Monitoring, STEAM

Resources: Dr. Loukas Katikas (EA)

Authors: Dr. Seda Özdemir-Fritz, Dr. Lothar Kurtze (FTP-Europlanet)

Providing a comprehensive collection of engaging, digital and hands-on classroom activities that empower students to understand, assess, and mitigate light pollution through art, science, and practical exploration, fostering environmental awareness and preserving the natural beauty of the night sky.

Outline

- CliC – PoLiT educational toolkit in a nutshell
- Background information & Teacher's Handbook
- Ideas to support school & out of school activities
- Guidelines, manual & support material
- Pedagogical Framework
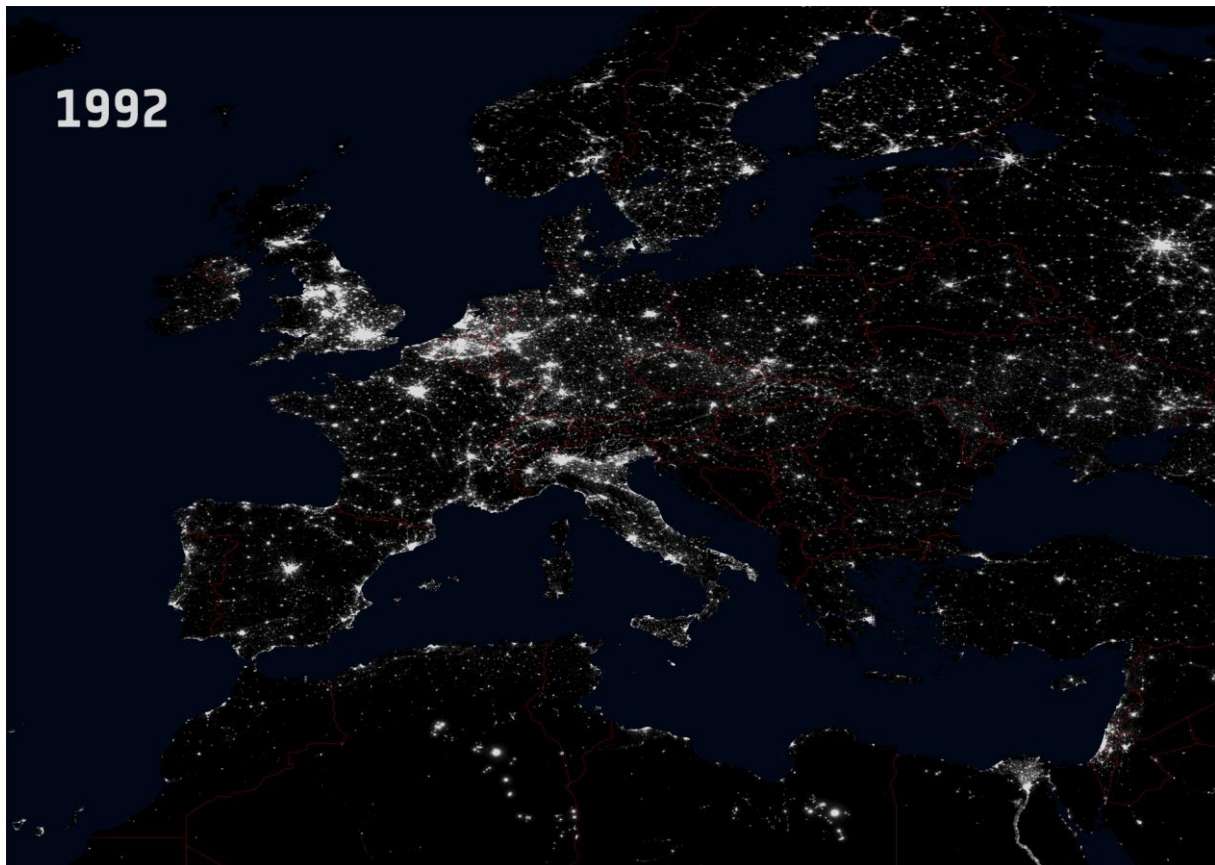
Toolkit Materials

- Teacher's handbooks
- Students' presentations
- Lesson Plans
- Assessment tools

Description

1. As part of the support offered to the schools, teachers and students that will be involved in the implementation process, the project team will **identify and develop a collection of guidelines and support materials in the form of a toolkit**.

2. This toolkit will employ transdisciplinary activities targeted at **Upper Primary and Secondary students (ages 9 - 15),** relating **light pollution with Sciences, Arts, & Humanities**.

3. The use of **new technologies and digital tools** will be encouraged in all activities. These instruments will assist students and teachers in making their own discoveries and share them with their communities, thus developing their **problem-solving, communication and collaboration competences** (project-based activities, outdoor experimentation, real – world problem solving).

Content

The CliC-PoLiT toolkit will provide support that covers the following aspects that are crucial to enable successful piloting in schools:

► **Background information** on Light Pollution, its effects on the environment, and its connection to Climate Change;

► Ideas and help to **support classroom activities**;

► **Connections between the toolkit activities and the pedagogical framework**, along with **suggested ways of implementation**;

► **A how-to guide to introduce the selected digital resources**.

► **Professional Development and Assessment Toolkit**

Timeline

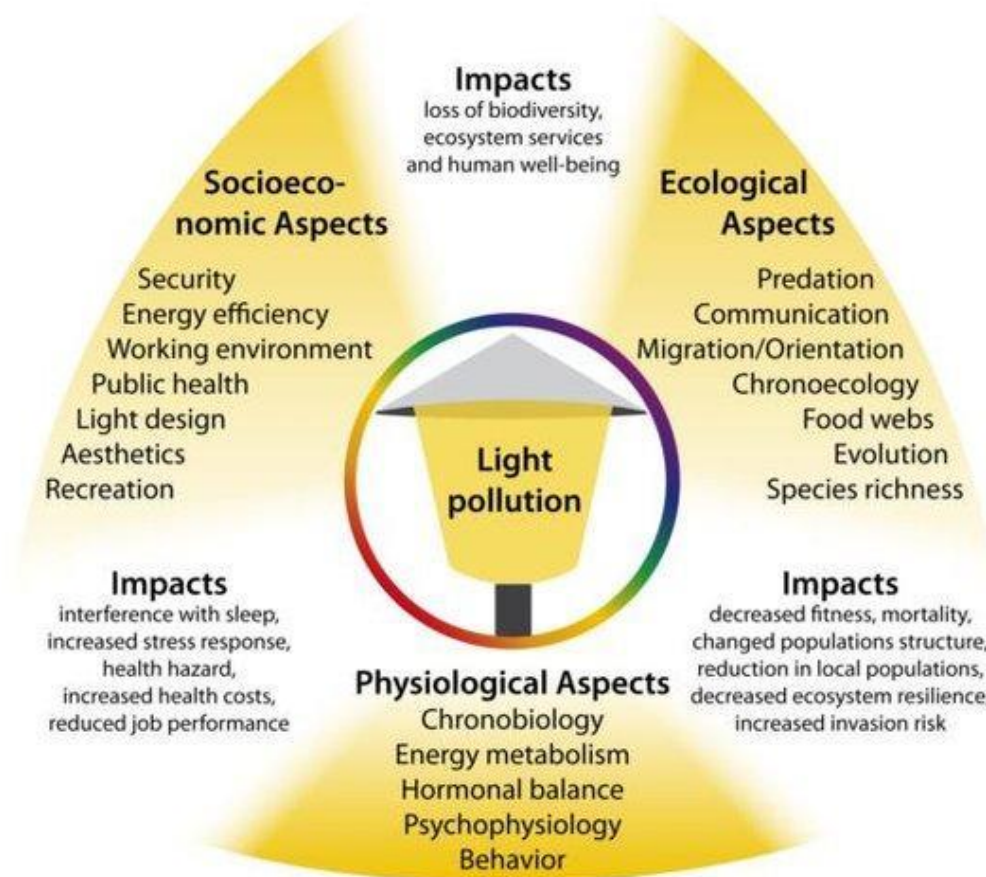The work of the educational toolkit is divided in the following tasks:

1. **Preparation of the first version of the toolkit**, including a **preliminary study of each country's curricular components**, **collection of educational resources** from all partners, and **testing during the CliC – PoLiT Summer School**.

2. **Implementation of suggestions**, design of the revised toolkit version, and implementation in participating schools.

3. **Evaluation of first year of implementation results**, applying changes, design and implementation of the final toolkit version.

4. **Final evaluation of results**.

Background Information

Definitions, Glossary and Examples

- What Is Light Pollution?

- Causes and types of Light Pollution

- Effects of Light Pollution

- Light Pollution monitoring and mitigation

- How can we reduce light pollution?

- Fun facts (or maybe not) about

Light Pollution!

Impacts
loss of biodiversity,
ecosystem services
and human well-being

**Socioeco-
nomic Aspects**

Security
Energy efficiency
Working environment
Public health
Light design
Aesthetics
Recreation

**Ecological
Aspects**

Predation
Communication
Migration/Orientation
Chronoecology
Food webs
Evolution
Species richness

Light
pollution

Impacts
interference with sleep,
increased stress response,
health hazard,
increased health costs,
reduced job performance

Physiological Aspects
Chronobiology
Energy metabolism
Hormonal balance
Psychophysiology
Behavior

Impacts
decreased fitness, mortality,
changed populations structure,
reduction in local populations,
decreased ecosystem resilience,
increased invasion risk

a) Monitoring light pollution (geospatial skills)

- How to work with satellite images of the Earth at night strikingly illustrate the extent of the distribution of artificial light sources associated with human settlement, industry and transport links, across its surface.

- How satellites work and measure the quantity of artificial light that includes a mixed signal of direct emissions from outdoor lighting that is not vertically shielded, as well as reflected light from the ground, buildings and vegetation, and light scattered within the atmosphere.

- Importance of monitoring and mapping artificial light. These signals have been increasingly used as an important indicator of urbanisation, industrial activity, and economic development. It has also been used as a measure of light pollution, which has long been a concern of astronomers but has more recently been proposed as an emerging major threat both to public health and natural ecosystems.

b) Analysing Patterns
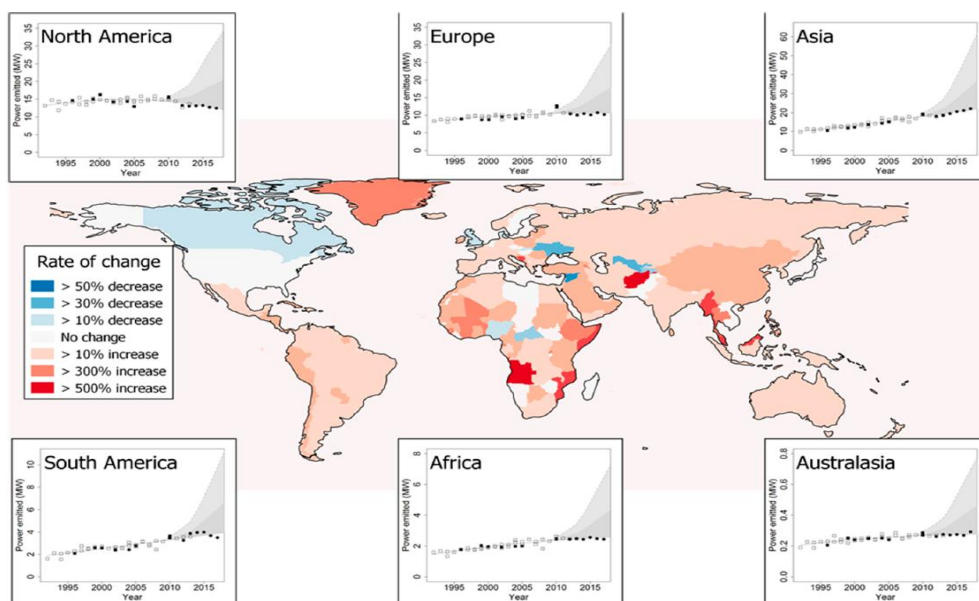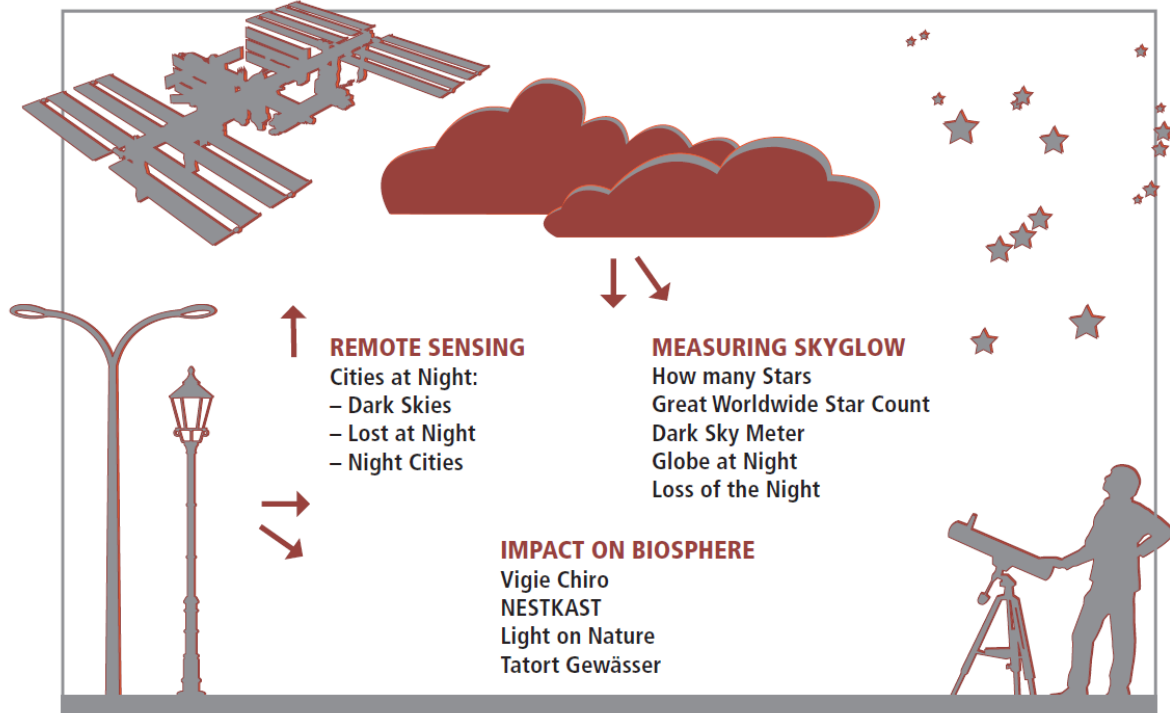

Source: Sánchez de Miguel et al. 2021

Graphs, charts & maps (examples)

Rate of change in artificial light at night represented as power output detectable by satellites from 1992 to 2017.
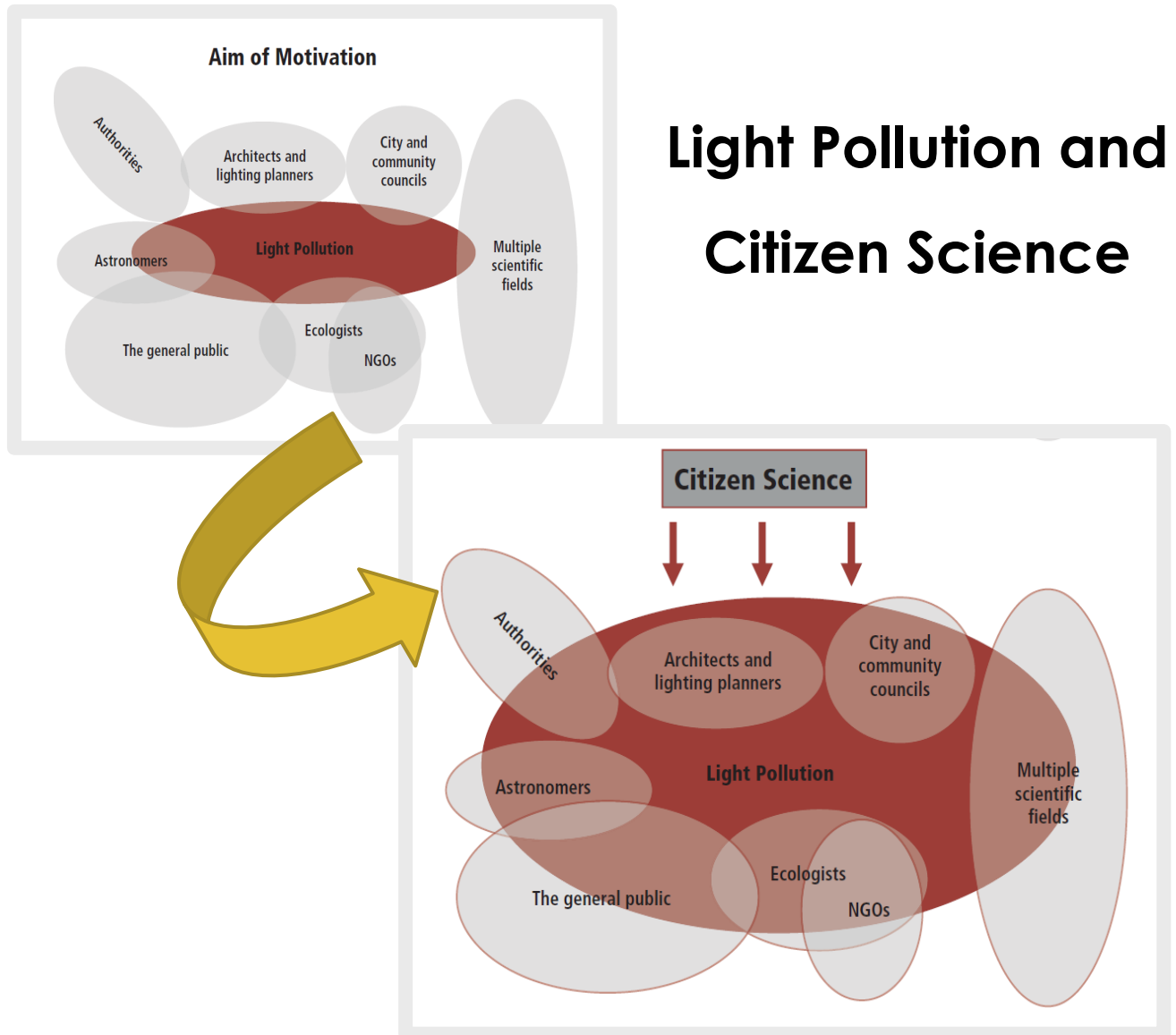
c) Citizen Science

Citizen Science & Light Pollution tracking and mitigation

List and ideas for citizen science projects focusing on artificial light at night and changes of nightscapes.

REMOTE SENSING
Cities at Night:
– Dark Skies
– Lost at Night
– Night Cities

MEASURING SKYGLOW
How many Stars
Great Worldwide Star Count
Dark Sky Meter
Globe at Night
Loss of the Night

IMPACT ON BIOSPHERE
Vigie Chiro
NESTKAST
Light on Nature
Tatort Gewässer

Source: Schroer et al. 2018

Light Pollution and Citizen Science

Source: Schroer et al. 2018

d) Sustainable Development

Energy Performance Variables	Aspect	Indicator	Type
Energy consumption in an area	Energy consumption for an area	Number of luminaires/area New luminaires in non-lit areas	System System
Rebound effects	Predicted energy savings will be underestimated	Percentage (rebound effect)	System
Energy efficiency	Energy efficiency based on energy and light per km road (per year)	W/lx per km road W/(cd·m^2) per km road	Energy efficient
Energy performance indicators in accordance with EN 13201-5	Annual energy consumption indicator (AECI)	Wh·m^{-2}	Energy efficient
	Power Density Indicator (PDI)	W/(lx·m^2)	Energy efficient
Luminous efficacy	Increase energy to light output	lm/W	Energy efficient
Luminous efficiency	Increase energy to light output compared to 100%	%	Energy efficient
Mesopic design or spectral distribution of the light source	Maximize visual performance and energy savings	S/P ratio	Energy efficient
		Correlated color temperature, degrees Kelvin (K)	Energy efficient
Light loss factor and lamp lumen depreciation	Minimize energy waste in the design and use stages (by accurate values of LLF or LLD)	Light loss factor (LLF), lamp lumen depreciation (LLD) or maintenance factor constant light output (CLO)	Energy conserving Energy conserving
Controlled dimming or adaptive/smart/dynamic systems	Energy savings in accordance with demand or schedule	Percentage savings (kWh/year)	Energy conserving
Surface luminance	Energy savings through increased luminance by changing the surface characteristics or adapting light levels to changed surface conditions	Percentage savings (kWh/year) due to intelligent lighting compensation for surface characteristics	Energy conserving
Legislation or regulations	Restrict the use of light sources, or spatial or temporal distribution of light	For example, implementing principles of "as low as reasonably achievable" (ALARA) or requirements on energy efficiency labelling	System, energy efficient or energy conserving
Optimized lighting design	Different implementations of optimization in the design process	For example, adaptation to current conditions or settings, or digital optimization	System, energy efficient or energy conserving

Source: Calluna et al. 2020

Linking Light Pollution to the EU Green Deal and SD goals.

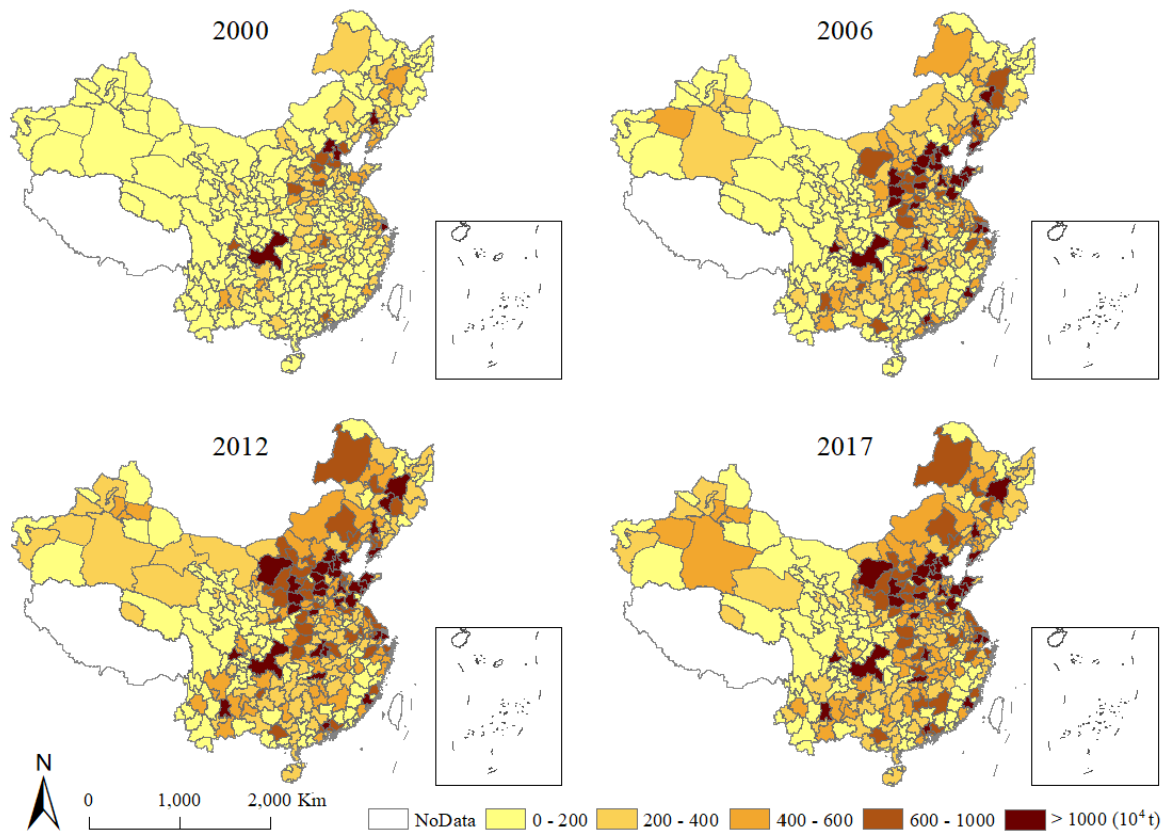Energy performance variables, aspects, indicators, and type.

Energy performance, consumption, efficiency, or energy conservation examples.
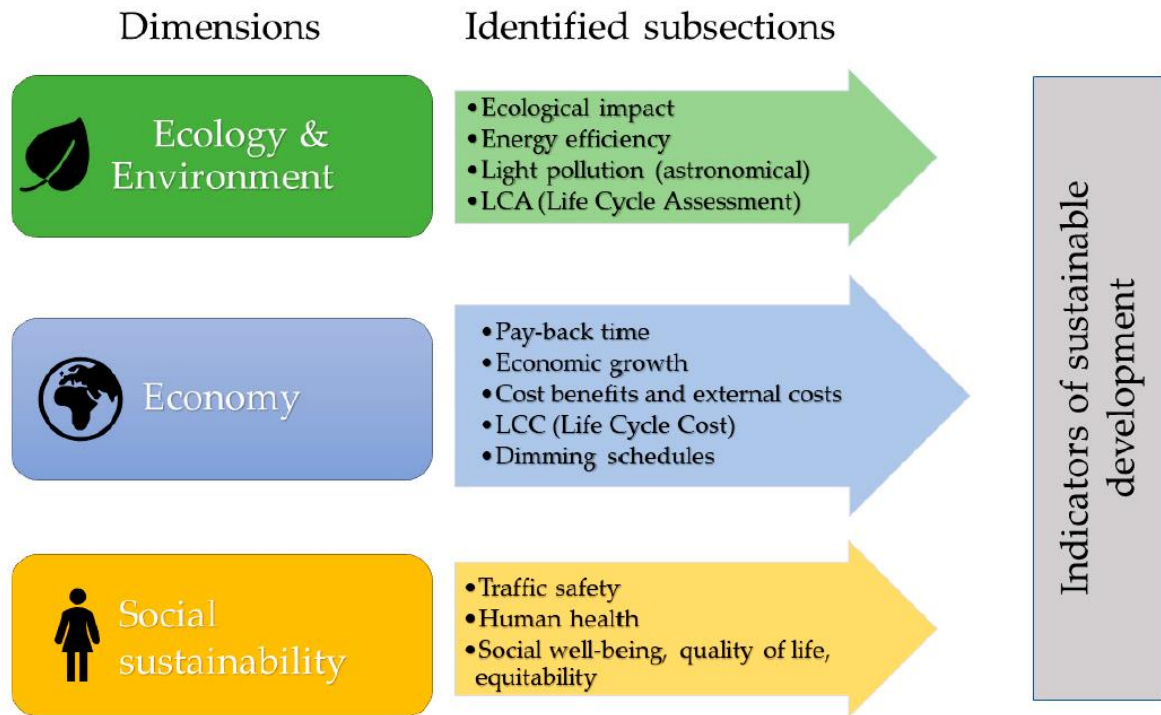
Source: Calluna et al. 2020

Overview of the dimensions and identified subsections in the framework of indicators of **sustainable development for exterior lighting.**

## e) Climate Change

Source: Sun et al. 2020

Spatial distribution of carbon emissions at the city level for the periods 2000–2017. Correlating Light Pollution & Air Pollution.

Light Pollution and Climate Change

There are two ways for light pollution to affect climate change;

Direct Way : With the destruction of nitrate radicals (which cleanse our air)

Indirect Way : Wasting resources (energy consumption) that pollutes air

Source: Stark et al. 2010
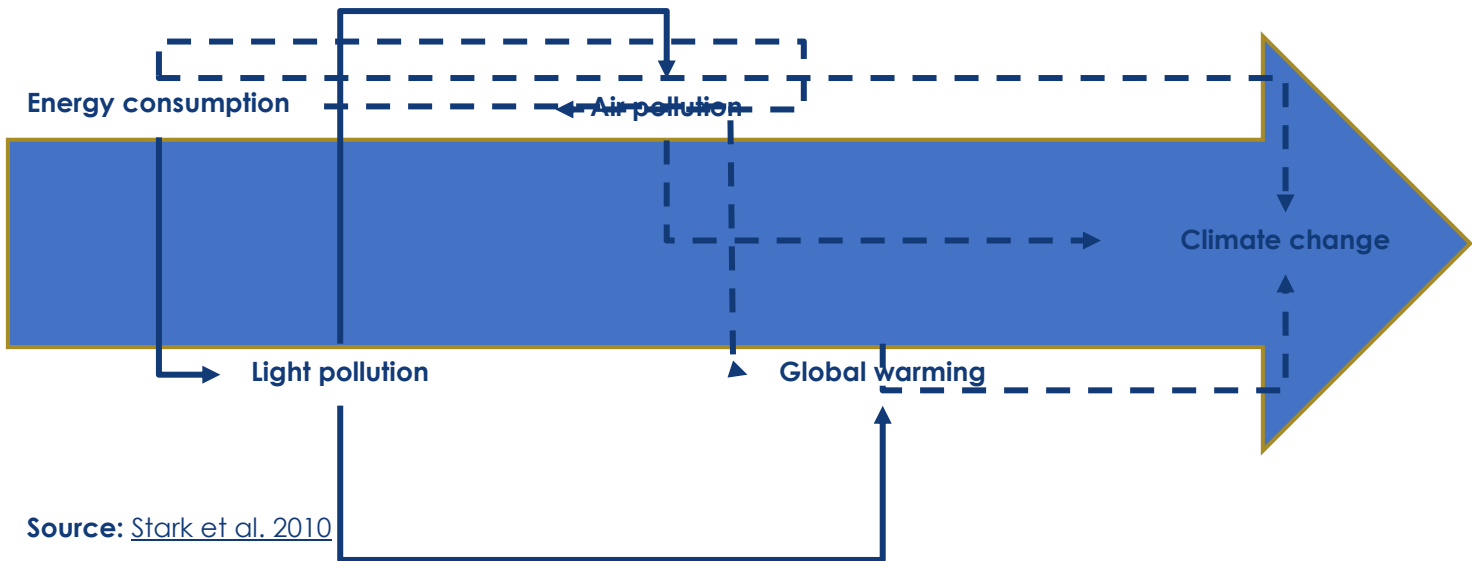
e) Biodiversity
Effects of Light Pollution

Light pollution disrupts ecosystems, from nocturnal to diurnal species: Nocturnal species are adapted to primarily be active at night -- from hunting for food, to reproduction, to pollination, to regulating body temperature. Diurnal species are adapted to primarily be active during the day. Diurnal species also require darkness to develop, navigate and survive.
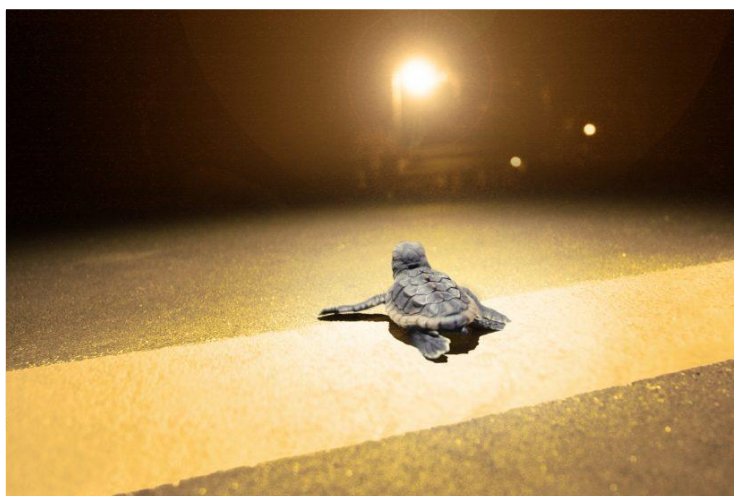
- **Light Polluted Cities are Deadly for Birds**

- **Light Pollution is Contributing Significantly to Insect Apocalypse**
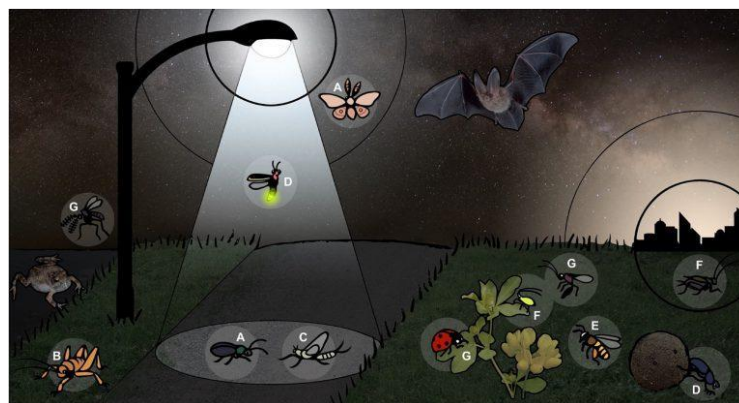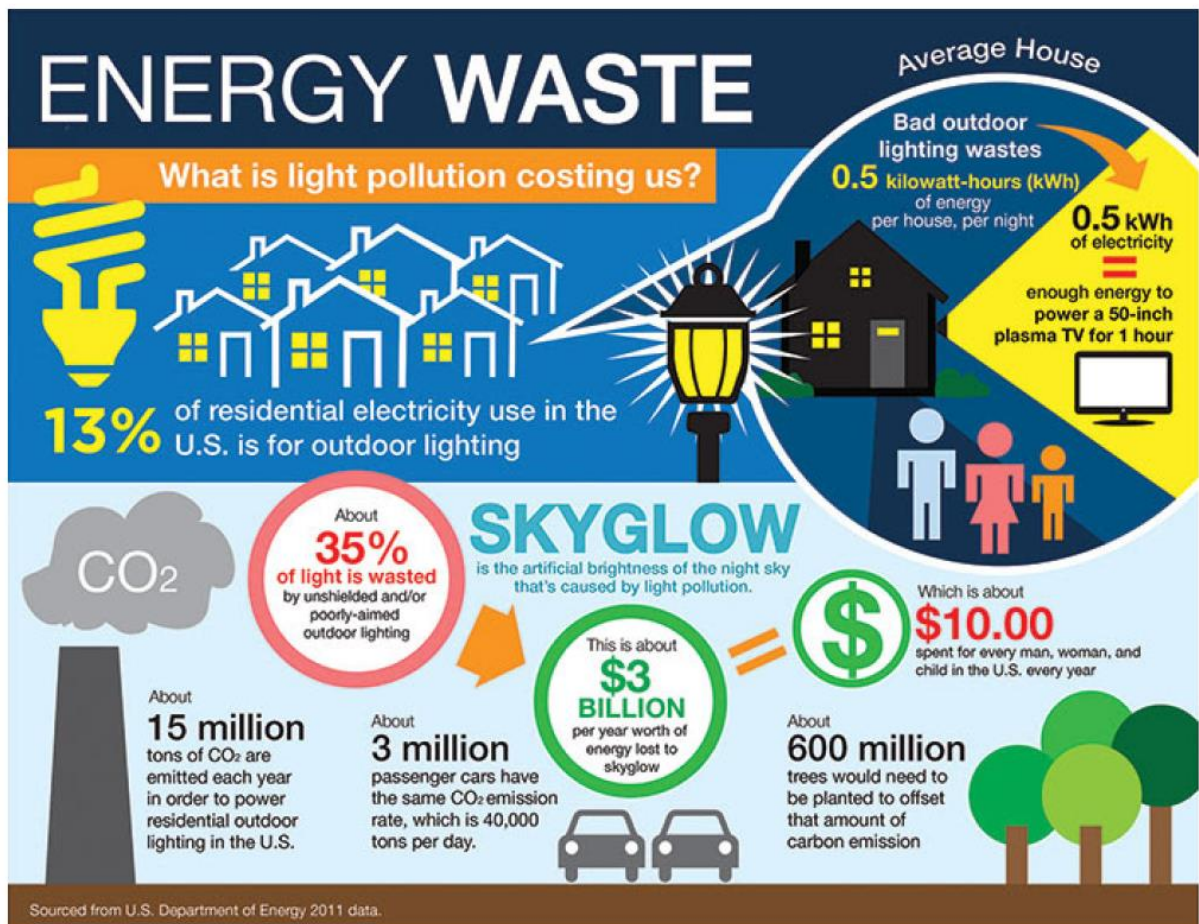

- **Bright Lights Disorient Sea Turtle Hatchlings**

Source for images: International Dark Sky Association

f) Energy Consumption
Effects of Light Pollution

Light pollution wastes energy: Light pollution wastes a lot of energy. 40,000 tons of carbon dioxide enters the atmosphere -- every day -- to produce the energy for unnecessary outdoor light. 600 million trees would need to be planted to offset that amount of CO2!

Source: https://www.caro.ie/projects-research/case-studies/improving-public-lighting-energy-efficiency

g) Energy Efficiency
Social

The **social benefits of a LED** lighting system include providing a safer environment, helping to lessen street crime and the fear of crime, and reducing the number and severity of night-time accidents.

Environmental

The **energy-efficient lighting project achieved 68% savings** in energy spending and has made a significant contribution to energy efficiency target of 33% by 2020 relative to 2009 energy usage.

Is LED lighting systems a viable option towards light pollution mitigation?

	Annual Energy (kWh)	Annual costs (Euro)	Annual CO2 (kg)
Before project	1,091,873	148,713	580,876
After project	346,300	47,166	184,231
Savings	745,573	101,547	396,645
% saving	68%	68%	68%

Source: https://www.caro.ie/projects-research/case-studies/improving-public-lighting-energy-efficiency

LED or NO LED

Egypt is one of the places on the planet where the massive use of high-intensity white LED street lighting.

The contrast with the areas of Cairo that still have orange street lights speaks for itself. Cairo, 5 May 2021.

Discussion: LET'S DEBATE !!!

Source: https://www.equaltimes.org/light-pollution-the-white-light?lang=en#.Yr6SmXZBzi2

Seen from space, Las Vegas looks like a strip of incandescent light, mostly white in colour. In terms of light pollution, **it is clear that what lights up Las Vegas does not stay in Las Vegas.**

Source: https://www.equaltimes.org/light-pollution-the-white-light?lang=en#.Yr6SmXZBzi2
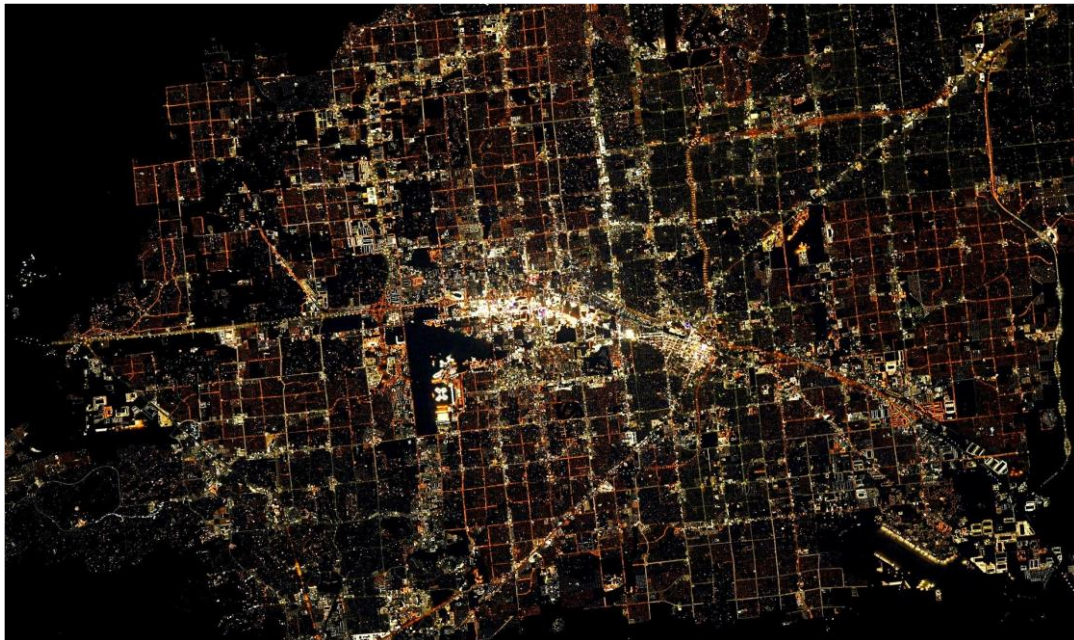
Discussion: Is this sustainable development?

Ideas to support school activities

Wildlife Workbook (includes games or activities about wildlife and light pollution)

- Workbook for ages 5-9
- Workbook for ages 6-12

Individual Activities and Games from the Wildlife Workbooks

Ages 5-9

- Animals of the Night Word Search
- Lost Moth Dot to Dot
- Save_the_Stars_Ages 4-8

Ages 5-12

- Owl Coloring page
- Sleep Tight Maze
- Turtle Maze

Ages 6-12

- Light Pollution and Wildlife Crossword Puzzle
- Wildlife_Word_Search

EXISTING MATERIAL

- Wildlife_Connect_the_Dots
- How can schools fight light pollution?
- Diorama of the Night Art Project Ages 6-12
- Protect our Night Sky/Reduce Light Pollution Ages 11-15 (12-page PDF of information and activities from the Bush Telegraph, published by the nonprofit NaDeet, the educational core of NamibRand International Dark Sky Reserve, Africa's first International Dark Sky Reserve
- Mini Page on Light Pollution Ages 8-10 (4-page PDF about light pollution and good lighting)

ACTIVITY: **How can we reduce light pollution?**

Protecting the night sky starts with YOU!

1 Light only what you need

2 Use energy efficient bulbs and only as bright as you need — 5w

3 Shield lights and direct them down

4 Only use light when you need it — AUTOMATIC TIMER

5 Choose warm white light bulbs

6 Join IDA! We need your help to continue the fight against light pollution. ida INTERNATIONAL DARK-SKY ASSOCIATION darksky.org

LET'S START A CAMPAIGN!

LET'S TRY THIS GAME!

[Light Pollution Simulator](#)

Create new material – Analyze data

Let's track Light Pollution from space! Click on the image below.
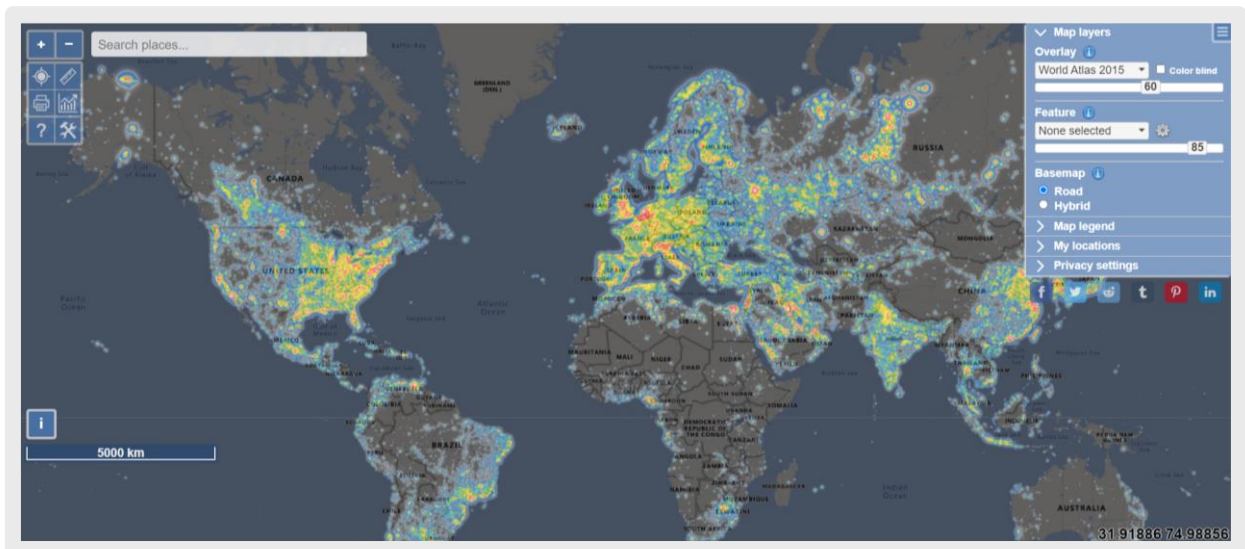
**How can we reduce light pollution?**

1. First, you can turn off your lights at night, or close the curtains.

2. Then look at the lights outside your house. Can they be turned off?

3. Or can motion sensors be installed so they only come on when needed?

4. Glare from outdoor lighting can be reduced by shielding light fixtures. You can talk to friends, family, and guardians about making some of these changes at home!

5. LED lights are often used outdoors. But LEDs can harm humans and animals. It's safer to use lights and filters that are coloured red or yellow.
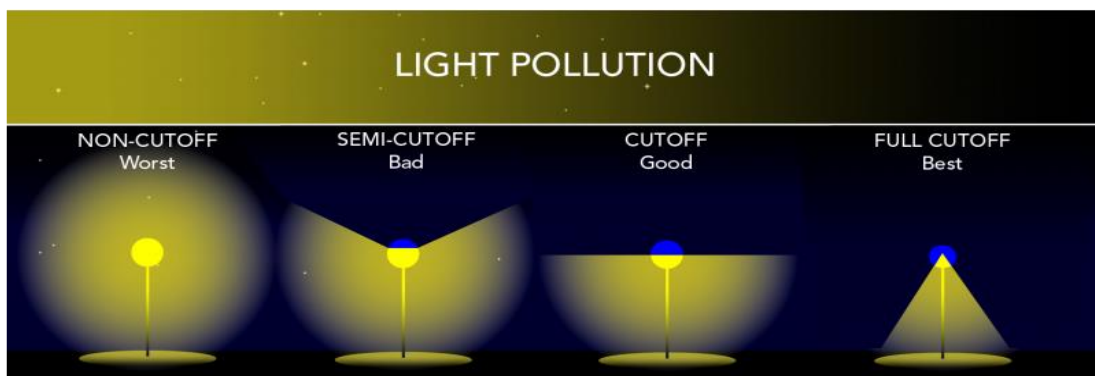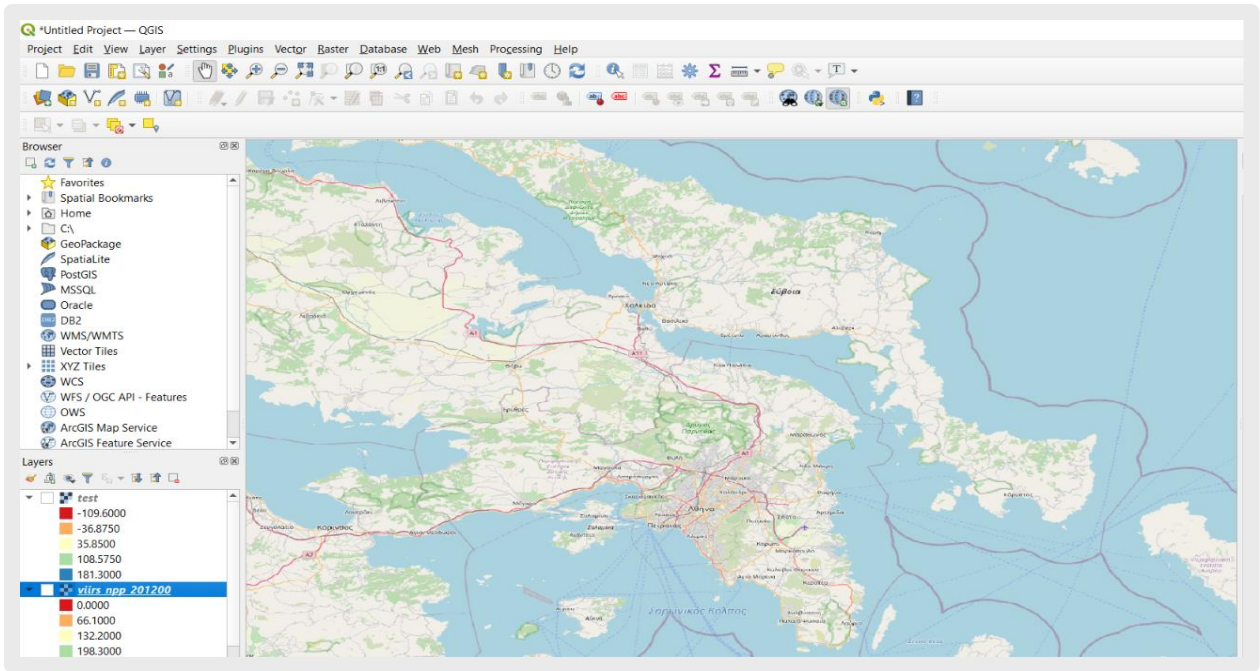

6. **Make your contribution and convince others!**

Guide to introduce digital resources

Step 1: Install the Plugins needed to run the activity (QuickMapServices)
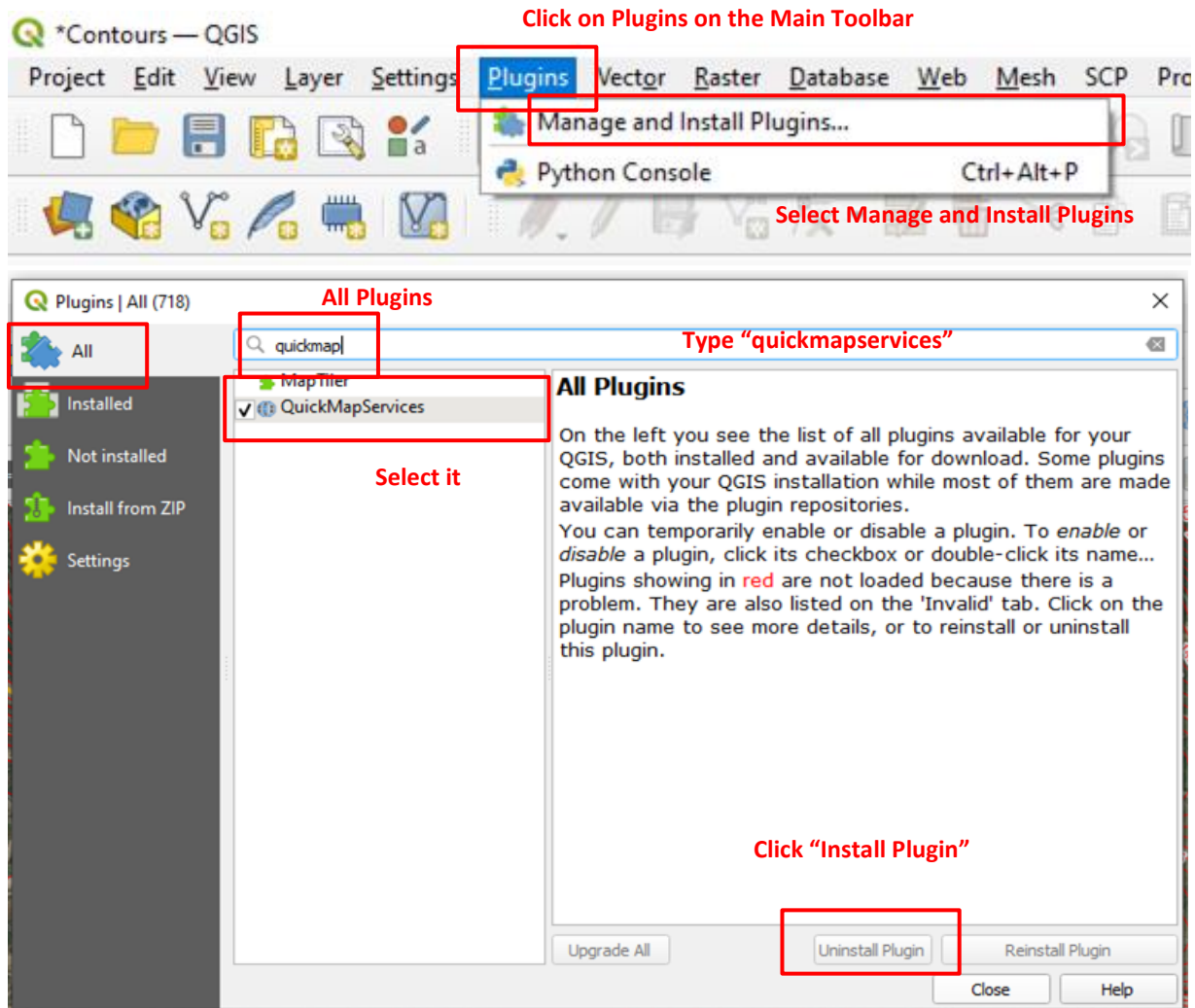

You can load the Basemap using the Main Toolbar on top: **Web > quickMapServices > OSM > OSM Standard. The result is shown below!**

In the platform you can see the **light pollution levels at global scale**.

In particular, you see the **radiance levels at night**, as seen from the satellites.

On the right corner you may select different light pollution maps per year (i.e. from 2012 - 2021), you can change the basemap layer, change the transparency level, see the map legend or even to save different locations around the world.
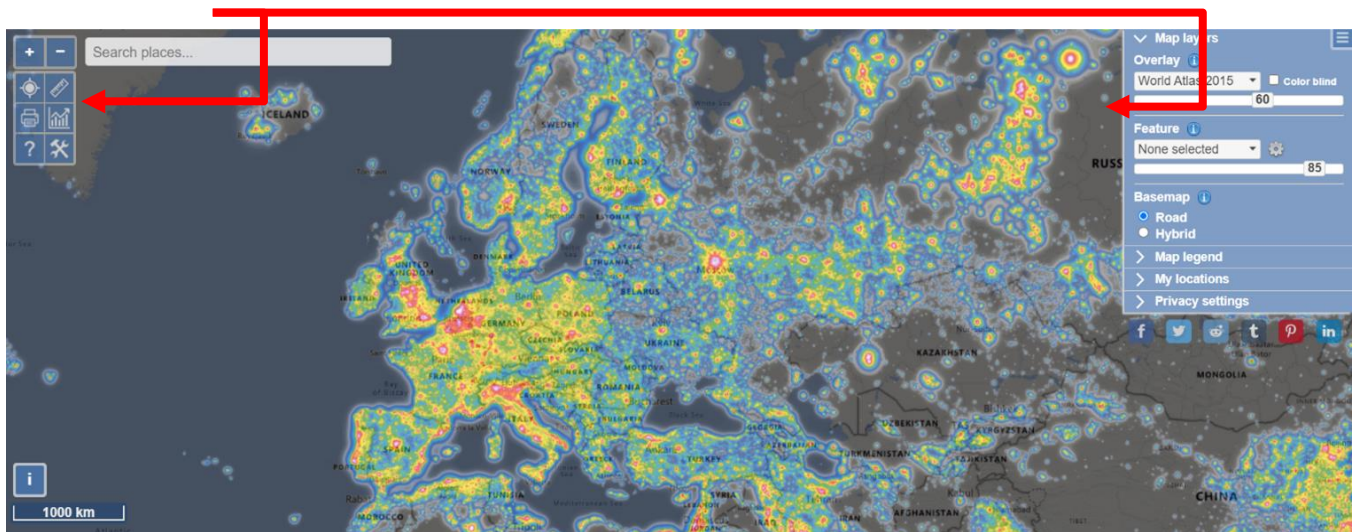
Using NASA WorldView to download real light pollution satellite images.
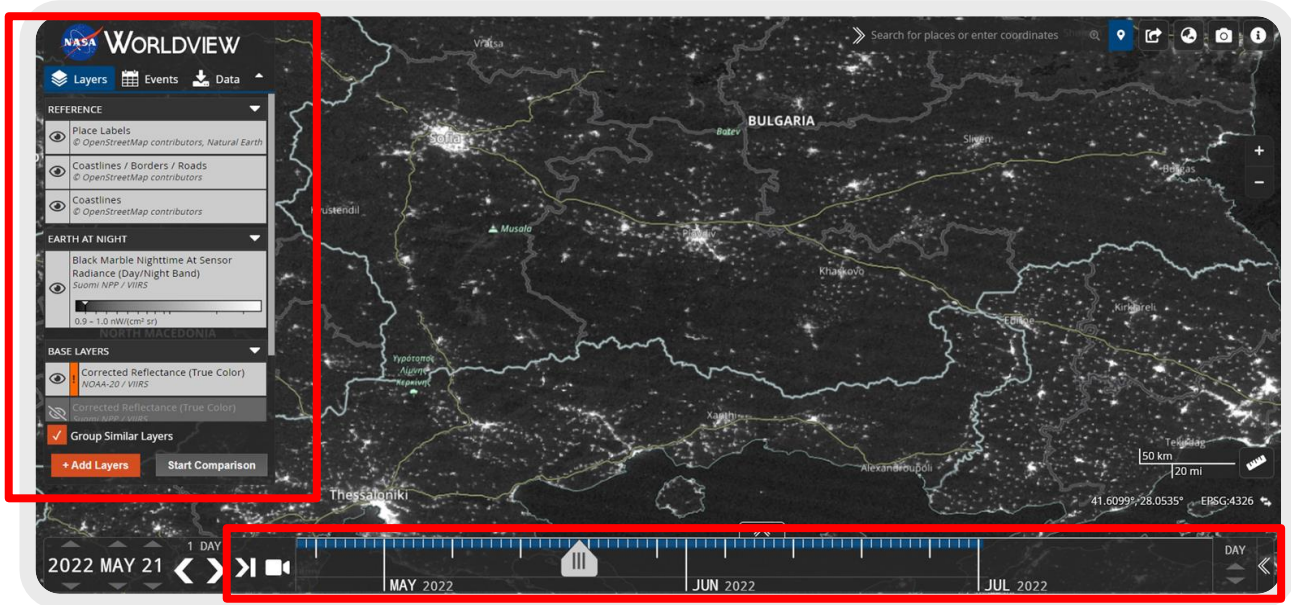
Changing the levels of light pollution in Stellarium

Stellarium simulates light pollution and is calibrated to the Bortle Dark Sky Scale where 1 means a good dark sky, and 9 is a very badly light-polluted sky. The box for 'light pollution data from location database' should remain unchecked to allow the user to increase or decrease levels of light pollution.

The dialogue box can be closed by 'x' on right hand side.

There are of course so many other possibilities of learning using Stellarium and one is encouraged to explore freely or research the User Guide PDF on stellarium.org

Fig. 7 Adjusting light pollution level in the View dialogue box.

To Quit Stellarium click the [ ] button or Ctrl + Q .

PEDAGOGICAL FRAMEWORK

**Why Light Pollution and overall, Climate change topics are important for DBR?**

► **Design Based Research (DBR)** integrates two endeavours – **development and research** – in the process of designing artefacts (teaching materials, learning strategies, curricula, etc.) for school practice.

► **Light pollution** provides a number of aspects going beyond mere physics subject matter and **involves social, environmental and health issues**.

► In addition, it is a relatively **new research field** (past two decades). This is usually an interest **generating momentum for students as they get the feeling of involvement in current research**.

Adopting the Design For Change (DFC) Process, a standard four-step process to guide students to develop their projects is proposed:

► **Feel:** Students identify problems or challenges in their local communities. Students observe problems and try to engage with those who are affected, discuss their thoughts and ideas of solution in groups, and plan actions based on scientific evidence.

► **Imagine:** Students envision and develop creative solutions that can be replicated easily, reach the maximum number of people, generate long-lasting change, and make a quick impact. They are meeting external actors, they are looking for data to support their ideas and they are proposing a series of solutions.

► **Create:** Students are implementing the project and they are interacting with external stakeholders to communicate their findings.

► **Share:** Students share their outcomes through posters, scientific papers, text, photos, video, or slideshows as members of the Dark Sky Rangers community.

Inquiry-based Approaches

► Use constructivist approaches to learn in general as well as an emphasis on a context-oriented or competence – oriented structure of the learning path.

► Provide the engagement-phase to grasp the phenomenological aspect of light pollution and problems connected to its existence. Only after this cognitive activation and the generation of problem awareness, students are supported to acquire relevant scientific knowledge to identify questions and to draw evidence-based conclusions.

► For structuring the learning paths in such a way, inquiry-based approaches will be used (5E-Model - engage, explore, explain, elaborate, evaluate).
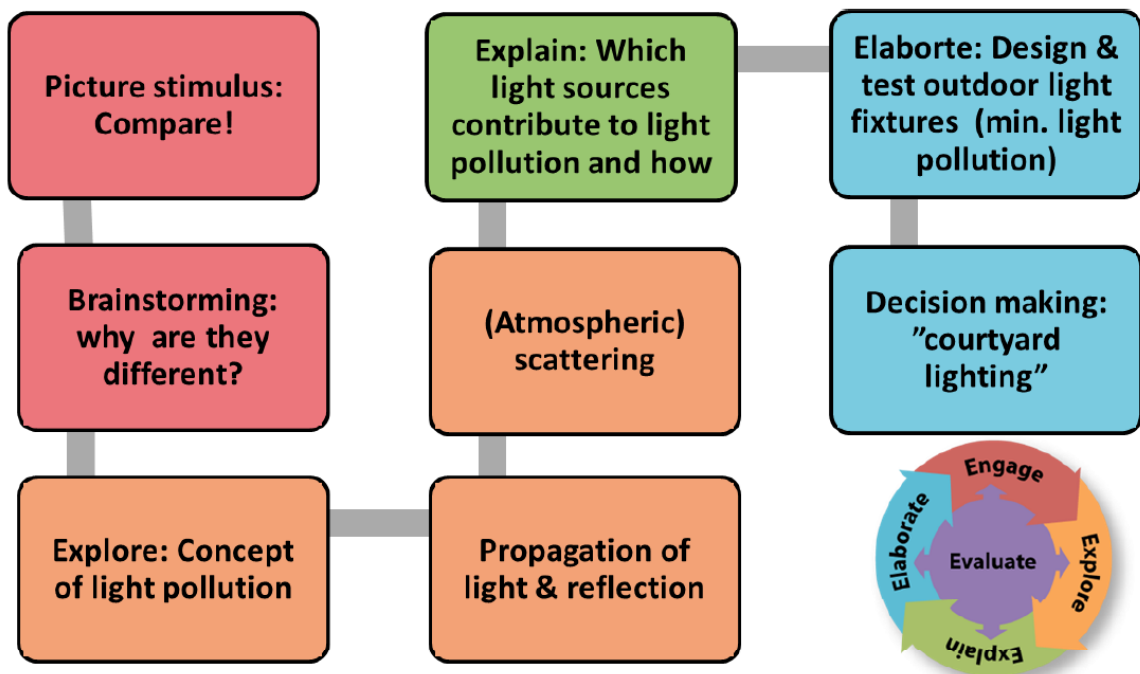
Source: Haagen-Schützenhöfer and Kopper, 2019

Engineering Approaches

1. **Define:** Explore, discuss, and build understanding of the problem (4 hours).

2. **Deeper investigation** about the problem (4 hours)

3. **Devise:** Create a plan to solve the problem (3 hours)

4. **Select** the best possible solution (1.5 hours)

5. **Code** implementation or **prototype** co-creation (5 hours)

6. **Solutions** test and evaluation – Review and Revise (2 hours)

7. **Communicate** results (2 hours)
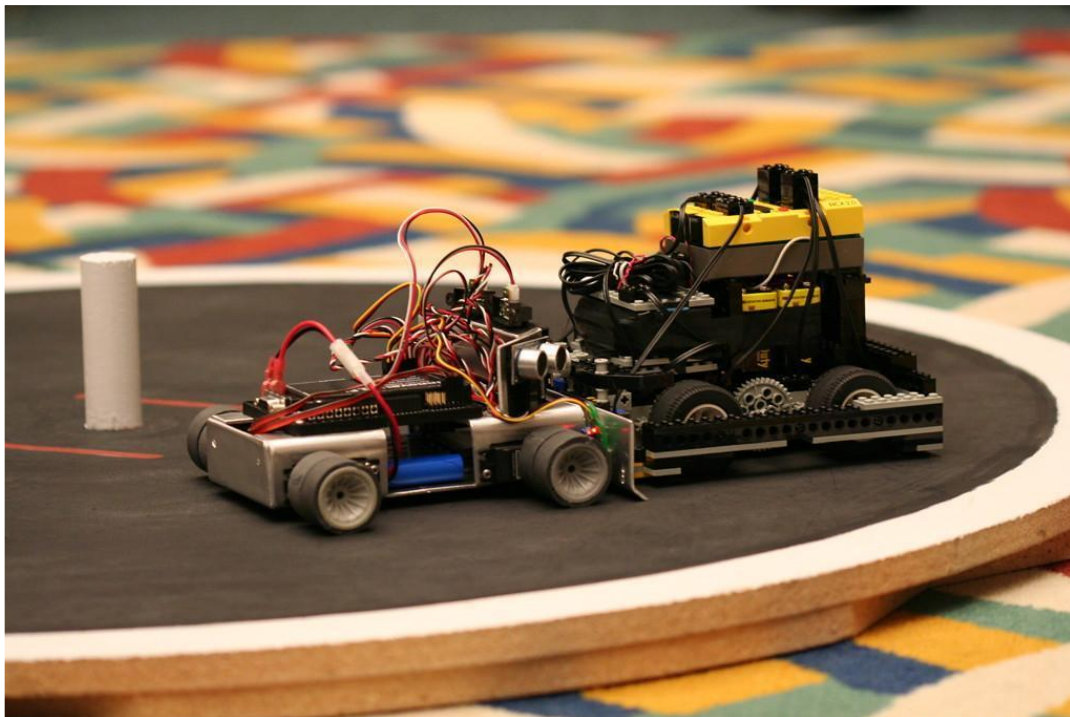
Robotics Competitions – Coding and Engineering skills

This Photo by Unknown Author is licensed under CC BY-SA

21ˢᵗ century skills

Debate science & 21ˢᵗ century skills

1. Develop critical thinking skills

2. Demonstrate collaboration, consensus building and cooperation

3. Apply skills in oral, visual and written literacy

4. Synthesise and communicate information

5. Develop media literacy skills

6. Demonstrate decision-making and problem-solving skills

Student Parliament

Green Skills

GreenComp: The European sustainability competence framework by JRC

12 competences organised into the four areas below:

Embodying sustainability values, including the competences

• valuing sustainability

• supporting fairness

• promoting nature

Embracing complexity in sustainability, including the competences

• systems thinking

• critical thinking

• problem framing

Envisioning sustainable futures, including the competences

• futures literacy

• adaptability

• exploratory thinking

Acting for sustainability, including the competences

• political agency

• collective action

• individual initiative

27

⇒<u>Note to Educators:</u> The toolkit encourages the use of new technologies and digital tools to enhance problem-solving, communication, and collaboration skills through project-based activities and real-world problem-solving. Teachers are encouraged to leverage these materials for an engaging and impactful learning experience, fostering sustainability values and green competences among students.