From satellite to soil - Sustainable Agriculture.

Co-funded by the European Union

Information

BioBeo Bioeconomy Definition:

"Bioeconomy is a systems-based approach that seeks to replace fossil resources in a sustainable manner with renewable biological resources from terrestrial and marine ecosystems – such as forests, crops, animals, fish, microorganisms, organic waste, and agricultural side streams, to produce food, feed, fibres, energy, bio-based products, and services within a circular economy framework designed to optimise resource use based on a cascading hierarchy of utilisation options. A sustainable and circular bioeconomy requires the application of education and training programmes, scientific research, technology, and innovation with the aim of not only creating economic value, but also regenerating and expanding ecosystems and biodiversity as well as improving the health and the well-being of society. By addressing these systemic changes in the economy, environment, and society, the bioeconomy contributes to achieving a better and more sustainable future where no one is left behind."

Organisation: E3STEM

Country: Greece

Topic: From satellite to soil - Sustainable Agriculture.

Narrative: Soils store carbon, water, and nutrients for plants. They play an important role in the challenges of climate change, the circular economy, human and environmental health, and water resources. Good soil health and nutrition is an essential part of the circular bioeconomy, in which bio-based solutions, derived from renewable raw materials and developed using industrial biotechnology, also play a role. For example, biodegradable and compostable plastics, both biobased and conventional, can also contribute to high-quality bio-waste. They are designed for specific applications and follow specific processes for end-of-life management, including separate collection and organic recycling. Bio-waste, in turn, can be used to produce high-quality compost and organic fertilizers that help restore soil organic carbon, increase soil fertility and combat desertification[1].

Forestry is part of the bioeconomy on various levels. Not only do forests provide the air we breathe and serve a recreational purpose, but they are also the origin of many biobased materials of the circular bioeconomy. Apart from their various functions in the bioeconomy ecosystem, they can serve as locations to link natural and urban environments. Whilst forestry products are becoming increasingly attractive from a sustainability perspective and are a major component of the circular economy, there are massive global disparities in the governance of forestry activities worldwide.

Biological raw materials can be transformed into almost any product we know from our everyday lives. BioBeo will also provide an overview of possible products, based on the storylines and concrete contexts that will be developed along the curriculums.

Methodology/ies: brainstorming, inquiry-based learning, engineering design, Active Learning, Guided Discovery.

SDG: 8,12,13, 15,17

[1] https://www.agro-chemistry.com/news/soil-health-essential-part-of-circular-bioeconomy/

8: Decent Work and Economic Growth, 12: Sustainable Consumption and Production, 13: Climate Action, 15: Life on Land, 17: Partnerships for the goals.

Age group: Secondary Education (Ages 14 – 18).

Curriculum integration: Environmental Sciences, Science, Biology, Chemistry, Physics, Agriculture

The following themes are addressed by this Material:

Inter-connectedness	Interconnectedness ☒	**Interconnectedness** reflects the role of the biosphere and natural environments in human well-being and holistic health and the undisputed ecological interconnectedness of all living things.
Outdoor Learning	Outdoor learning ☒	**Outdoor learning** is active learning in the outdoors where participants learn through what they do, through what they encounter and through what they discover.
Food Loop	Food Loop ☒	**Food Loop** encompasses farming, hospitality, retail, and energy production sectors. In terms of the circular economy, it focuses on the efficient use of by-products, and the overall reduction of food waste.
Forestry	Forestry ☒	Whilst **forestry** products are increasingly attractive in terms of sustainability, and are a major part of the circular economy, there are massive global disparities in the governance of forestry activity.
Life Below Water	Life Below Water ☐	**Life below water** refers to the conservation and sustainable use of all water bodies (like oceans, and marine resources but also rivers and lakes) for sustainable development.

Learning outcomes

Lesson 1

By this lesson plan activity, the students will be able to:

1. learn what soil is and what components it is made of

2. learn what Ph is.

3. discover the importance of soil health and soil pH to the crops.

4. identify the type of soil and its characteristics

5. develop critical thinking and research skills by doing research on the different types of soil.

6. develop critical thinking and research skills by doing research in the right manner to correct the soil Ph.

7. develop communication skills by collaborating with other students and presenting their project in the classroom.

Learning outcomes

Lesson 2

By this lesson plan activity, the students will be able to:

1. identify the benefits of sustainable forestry practices and the impact of deforestation on our planet.
2. identify the various products produced from forestry and understand their economic and environmental importance.
3. identify the different products produced in forests, and their uses.
4. develop critical thinking and research skills by conducting research on sustainable forestry practices and the products produced from forestry.
5. develop communication skills by presenting their research findings to the class.

Learning outcomes

Lesson 3

By this lesson plan activity, the students will be able to:

1. discover the importance of water retention in soil.

2. identify the water retention for every type of soil.

3. develop critical thinking and research skills by doing research on the water retention of soil.

4. be informed about sustainable and regenerative Agriculture and Agroforestry.

5. identify by the help of technology when soil needs fallow or crop change.

6. develop critical thinking and research skills by doing research to find the right farming method to ensure biodiversity.

7. develop communication skills by collaborating with other students and presenting their project in the classroom.

Learning outcomes

Lesson 4

By this lesson plan activity, the students will be able to:

1. be informed about how, using technology, can control the soil moisture.

2. learn about using open-source software.

3. calibrate the soil moisture sensor.

4. measure Soil Moisture using either Analog Output or Digital Output.

5. work in groups in a virtual classroom.

6. make electronic circuits.

7. develop critical thinking and research skills by choosing the right function of soil moisture sensor.

Learning outcomes

Lesson 5

By this lesson plan activity, the students will be able to:

1. Understand the chemistry and production processes of bio-based products.
2. Compare and contrast the advantages and disadvantages of bio-based products with traditional products.
3. Evaluate the potential of bio-based products for sustainability and environmental impact.
4. Analyze different applications of bio-based products and their potential to replace traditional products.
5. Develop critical thinking skills to understand the challenges associated with bio-based products and their commercialization.

Learning outcomes

Lesson 6

By this lesson plan activity, the students will be able to:

1. learn about soil and the importance of being healthy.

2. learn about sustainability and bioeconomy.

3. develop critical thinking and research skills by taking part in all the previous activities.

4. develop communication skills by presenting their job in the school festival.

Lesson Plan 1

Subjects: Science, Biology, Chemistry, Physics, Agriculture	**Title of Lesson:** Learning about the soil - Importance of soil PH. Manner to Correct it. **No. of Lesson 1 of 6**	
Date: Spring Term 2024	**Class:** Secondary education (14-18 years old)	**Time: Flexible** **Duration: 2 hours**
BioBeo Theme: Food loop, Interconnectedness, Outdoor learning.	**Keywords/Phrases:** bioeconomy, sustainable agriculture, soil, nutrients, sustainable agriculture, soil, nutrients, ph.	

Learning Outcomes:

By this lesson plan activity, the students will be able to:

1. learn what soil is and what components it is made of.

2. learn what Ph is.

3. discover the importance of soil health and soil pH to the crops.

4. identify the type of soil and its characteristics and the role of soil in a circular bioeconomy.

5. develop critical thinking and research skills by doing research on the different types of soil.

6. develop critical thinking and research skills by doing research in the right manner to correct the soil Ph.

7. develop communication skills by collaborating with other students and presenting their project in the classroom.

Resources/Materials/Equipment:

- Laptops
- Internet connection
- two glasses
- vinegar
- 3 teaspoons of baking soda
- Water
- Pine needles
- Wood ashes
- Ph measuring tapes / soil rapid test Soil Kit

Introduction:

We know that the soil and its quality are an important factor in the circular bioeconomy as far as agriculture is concerned. The repeated cultivation of a variety for a long period of time and the

improper care of the soil are two of the most important factors that lead to its destruction. Each crop has separate requirements for soil components, for this reason it is necessary to rotate the type of crop taking care of the correct enrichment of the soil with the necessary trace elements.

Soil Ph is one the chemical properties of soil which is related to properties that directly affect plant nutrition. Soil pH can affect nutrient availability in the soil. It is measured on a scale from 1–14. A pH of 7 is regarded as neutral, a pH below 7 moves the soil toward the acidic region, and a pH above 7 moves the soil toward the alkaline region. The optimal pH for soil nutrient absorption is between 6.5 and 7.5. Within this range, most soil nutrient elements will be available for crop uptake. However, below pH 6.5 or above pH 7.5, certain elements will become less available, even if they are present in the soil. That is why soil fertilizers need to be applied to some soils to compensate for lower availability of a nutrient due to pH issues[2.]

Development:

1. Discussing the importance of soil health in our life and where soil sits in the bioeconomy conversation. **[15 minutes]**

   Raise the interest of students by informing them about what the soil is, the reason of being important and the importance of soil health.

   https://www.youtube.com/watch?v=udseIcrUxvA

   https://www.youtube.com/watch?v=QtwMIIRX8TM

2. Division in 5 groups of 4-5 students each. **[5 minutes].**
3. Brainstorming about soil, the types of soil. **[30 minutes].**
   Students in groups read the articles below:

   https://en.wikipedia.org/wiki/Soil

   https://www.ctahr.hawaii.edu/mauisoil/a_comp.aspx

   https://www.nature.com/scitable/knowledge/library/what-are-soils-67647639/

   https://climate-woodlands.extension.org/basic-soil-components/

   https://pubs.nmsu.edu/_circulars/CR694B/

   In combination with the articles, the students will watch the following videos and they make concept maps or word clouds:
   https://www.youtube.com/watch?v=bgqea0E2eAY
   https://www.youtube.com/watch?v=idLDCWNTXgg

4. Students in groups perform an unplugged experiment (simulation) measuring soil pH and correcting it in a sustainable manner **[45 minutes].**
   Each group takes experiment procedure and materials. They act, keeping notes and photos of their observations and results.

[2] https://pubs.nmsu.edu/_circulars/CR694B/

Experiment procedure.

a. Fill the first glass halfway with vinegar.

b. Fill the second glass halfway with water and dissolve 3 teaspoons of baking soda in it.

c. Take a handful of soil and pour it into the glass with the vinegar. Does it foam heavily? Your soil is alkaline (pH>7).

d. Take a handful of soil and poor it into the glass with the soda. Does it foam heavily? Your soil is acidic (pH<7).

5. Students make research about which crop is suitable depending on the soil Ph, filling a table. **[15 minutes]**
6. Students explain their results of the unplugged Experiments**. [10 minutes]**
   Each group makes a presentation describing in a resume the experiment procedure and analyzing their findings.

Conclusion:

Lesson concludes with:

a. the presentation of students' concept maps and word clouds. These will be the cover page of their final project.
b. the discussion about the importance of soil Ph in agriculture and the importance of calibrating it by a sustainable manner.

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

Digital evidence (photos, videos, word clouds, concept maps).
Documented information: such as notes, photographs, videos, journal written by teacher in lesson flow, presentations.
Pupils' self-assessment: completing their learning surveys.

Literature and links

- What the soil is: https://en.wikipedia.org/wiki/Soil
- What the soil is: https://www.nature.com/scitable/knowledge/library/what-are-soils-67647639/
- What the soil is: https://www.ctahr.hawaii.edu/mauisoil/a_comp.aspx

- Basic soil components: https://climate-woodlands.extension.org/basic-soil-components/
- Soil components: https://pubs.nmsu.edu/_circulars/CR694B/
- Making word clouds program: www.wordart.com
- Making concept Maps free program: https://www.canva.com/graphs/concept-maps/
- Soil Health essential part of circular economy: https://www.agro-chemistry.com/news/soil-health-essential-part-of-circular-bioeconomy/
- EU Mission: A soil Deal for Europe: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-health-and-food_en.
- Why is soil pH important to farmers? https://www.youtube.com/watch?v=zQowljL8e5E.
- John Idowu, Rajan Ghimire, Robert Flynn, and Amy Ganguli, 2019, "Soil Health—Importance, Assessment, and Management". College of Agricultural, Consumer and Environmental Sciences, New Mexico State University, Circular 694B, https://pubs.nmsu.edu/_circulars/CR694B/ .
- Soil pH – Information on Everything You want to know", kalliergo forum Ilias Antonopoulos,2019), https://www.kalliergo.gr/edafos-xoma/ph-edafos-plirofories/ .

Lesson Plan 2

Subject(s): Environmental Sciences, Science, Biology, Chemistry, Physics	**Title of Lesson:** Making plastic from potatoes **No. of Lesson** 1 of 1	
Date: Spring term 2024	**Class:** Secondary Education (14 – 18 years old)	**Time:** 10.00 am – 12.00 pm **Duration:** 2 hours
BioBeo Theme: Food loop	**Keywords/Phrases:** bioeconomy, circular economy, bio-based products, plastic from potatoes.	

Learning Outcomes:

By this lesson plan activity, the students will be able to:

1. Understand the chemistry and production processes of biobased products.
2. Compare and contrast the advantages and disadvantages of biobased products with traditional products.
3. Evaluate the potential of bio-based products for sustainability and environmental impact.
4. Analyze different applications of bio-based products and their potential to replace traditional products.
5. Develop critical thinking skills to understand the challenges associated with biobased products and their commercialisation in a circular bioeconomy.

Resources/Materials/Equipment:

- Potatoes
- Acetic acid (known as vinegar)
- Glycerin

Introduction:

Biobased products can make the economy more sustainable and lower its dependence on fossil fuels. For this reason, the EU has declared the bio-based products sector to be a priority area with high potential for future growth, reindustrialization, and addressing societal challenges. An assessment done by the European Commission has indicated that biobased products and biofuels represent approximately €57 billion in annual revenue and involve 300 000 jobs. According to forecasts, the bio-based share of all chemical sales will rise to 12.3% by 2015 and to 22% by 2020, with a compounded annual growth rate of close to 20%[3].

Biobased products are wholly or partly derived from materials of biological origin, excluding materials embedded in geological formations and/or fossilized. In industrial processes, enzymes are used in the production of chemical building blocks, detergents, pulp and paper, textiles, etc. By using fermentation and bio-catalysis instead of traditional chemical synthesis, higher process efficiency can be obtained,

[3] https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en

resulting in a decrease in energy and water consumption, and a reduction of toxic waste. As they are derived from renewable raw materials such as plants, bio-based products can help reduce CO2 and offer other advantages such as lower toxicity or novel product characteristics (e.g. biodegradable plastic materials)[4].

Development:

1. Brainstorming / Discuss the benefits of bioeconomy and circular economy
   [10 minutes]

   Use a video as a trigger to introduce the concept of bioeconomy
   https://www.youtube.com/watch?v=hx-jZmE-2_U

2. Students watch the video with the title "**The Bioeconomy starts here!**" and then do research to find biobased products.
   [10 minutes]

   Use the video https://www.youtube.com/watch?v=2xvXkOMRTs4 as a trigger to engage the students in the concept of biobased products.

3. Students in groups find a bio-based product and do research on how this product is produced. Compare and contrast the advantages and disadvantages of the biobased product with traditional products.
   [15 minutes]

   Use the following videos to **create a how to tutorial on how to create plastic from potatoes**:

   Produce starch from potatoes: https://youtu.be/UihU15GsWxU

   Bioplastic- Potato Plastics: https://youtu.be/90ZbC5rtmTk

4. Students create plastic from potatoes using the how-to tutorial created in the previous phase.
   [45 minutes]

   Each group creates plastic from potatoes.

   This stage assumes that students have starch from potatoes and follow the second phase of the experiment to create the plastic.

   Another option would be to do the experiment in 2 different days. The first day to create the starch, and the second day to create the plastic.

[4] https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en

5. Students create a presentation or a video that describes the **step-by-step procedure** followed to create their **own** plastic from potatoes.
   [40 minutes]

   Each group has to make a **presentation** on the subject to the class.

Conclusion:

Lesson concludes with all of us sitting in a circle discussing the European Union's strategy on plastics. The EU has been actively supporting the development of **Bioplastics** through ambitious and collaborative research that aims for a greater uptake that will help transform Europe's plastics' industry over the coming years[5].

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

- Digital photographic evidence/ IPad or class camera in use.
- Documented information: such as notes, photographs, videos, and learning stories, journal written by teacher in lesson flow.
- Art works produced by children (co-researchers) and photos of processes.
- Pupils' self-assessment: completing their learning surveys and follow on learning with class teacher and parents in the week between each lesson.

Literature and links

Biobased plastics. https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/bio-based-products-and-processes/bio-based-plastics_en

Biobased products. https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en

Biobased products. https://www.eubia.org/cms/wiki-biomass/bio-based-products/

Biobased products and processes. https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/bio-based-products-and-processes_en

[5] https://op.europa.eu/en/publication-detail/-/publication/8f4592e9-c501-11e7-9b01-01aa75ed71a1

Lesson Plan 3

Subject(s): Science, Biology, Chemistry, Physics, Agriculture.	**Title of Lesson:** Water Retention in Soil - Sustainable Agriculture **No. of Lesson 3 of 6**	
Date: Spring Term 2024	**Class:** Secondary education	**Time: flexible** **Duration: 2 hours**
BioBeo Theme: Outdoor learning, Interconnectedness, Food Loop, Forestry.	**Keywords/Phrases:** sustainable agriculture, soil, nutrients, water retention, Agroforestry, regenerative agriculture, soil, biodiversity, circular bioeconomy.	

Learning Outcomes:

By this lesson plan activity, the students will be able to:

1. discover the importance of water retention in soil.
2. identify the water retention for every type of soil.
3. develop critical thinking and research skills by doing research on the water retention of soil.
4. be informed about sustainable and regenerative Agriculture and Agroforestry.
5. identify by the help of technology when soil needs fallow or crop change.
6. develop critical thinking and research skills by doing research to find the right farming method to ensure biodiversity.
7. develop communication skills by collaborating with other students and presenting their project in the classroom.

Resources/Materials/Equipment:

- five different soil components (gravel, sand, silt, clay, and potting compost),
- five funnels,
- five coffee filters,
- five jars,
- one balance,
- one or more 50ml mess cylinders
- Laptops
- Internet connection
- Making comic software
- Making conceptual map software

Introduction:

Soil water holding capacity is a term that all farms should know to optimize crop production. Simply defined **soil water holding capacity** is the amount of water that a given soil can hold for crop use. Field

capacity is the point where the soil water holding capacity has reached its maximum for the entire field. The goal for agricultural producers is to maintain the field at or near capacity. When there is a deficit in the amount of water in the soil, the soil profile needs to be replenished by precipitation or irrigation. The key is for farmers to understand the nuances of soil water holding capacity and how to manage it so that the farm does not need to irrigate or suffer from a drought.[6]

Since the second half of the 20th century, national and international policies have encouraged farmers to produce more and at a lower cost. This model, characterised by its high mechanization, the massive use of inputs and the homogenization of landscapes, is now questioned by many farmers. Indeed, they are prisoners of a system that has led them to high-yield practices, endangering the maintenance of biodiversity and traditional landscapes. This is why an increasing proportion of farmers are now turning to an agriculture based on the understanding of ecological principles: they work with soil biodiversity, preserve the quality of water, rely on pest predators, favor protect wild pollinators; they plant hedgerows, restore ponds, sow flowering meadows, and adopt practices to reintroduce wild or cultivated biodiversity at all scales[7].

Development:

1. Students in groups perform an unplugged experiment for water retention in Soil [45 minutes]

   Division in 5 groups of 4-5 students each. Each group takes an experimenter's instruction sheet,50g of one soil component, 50 ml of water and one piece from the rest of the laboratory equipment. They act, keeping notes and photos of their observations and results.

   Experiment procedure.

   a. Weigh 50g of each soil component.
   b. Set a funnel with a coffee filter and put on top of the jar.
   c. Slowly, pour 50 milliliters of water over the components.
   d. Wait 5 minutes.
   e. Check how much water passed through the soil components using mess cylinders.

2. Each group explains its results and observations of the unplugged experiment by making a presentation analyzing its findings and creating a conceptual map **[15minutes].**

3. Students watch some videos and read two articles about the importance of soil health in a circular economy and the different manner of keeping the soil alive and productive **[15 minutes].**

   Industrial biotechnology solutions for sustainable agriculture. https://www.europabio.org/wp-content/uploads/2021/01/2020_01__I_R_Industrial-biotechnology-solutions-for-sustainable-agriculture.pdf
   Soil Health essential part of circular bioeconomy. https://www.agro-chemistry.com/news/soil-health-essential-part-of-circular-bioeconomy/
   Understanding Our Soil: The Nitrogen Cycle, Fixers, and Fertilizer. https://www.youtube.com/watch?v=A8qTRBc8Bws

[6] https://www.canr.msu.edu/news/why_is_soil_water_holding_capacity_important
[7] https://www.youtube.com/watch?v=MkhMkKIppZQ.

Agriculture and biodiversity, growing with nature. https://www.youtube.com/watch?v=MkhMkKIppZQ
Basics of Agroforestry. https://www.youtube.com/watch?v=jLZ0KtNx354
Can we create the "perfect" farm? https://www.youtube.com/watch?v=xFqecEtdGZ0.
What is Regenerative Agriculture? https://www.youtube.com/watch?v=fSEtiixgRJI.

4. Each group makes a comic for the importance of soil health in agriculture and circular ways to protect this. **[45 minutes]**

Conclusion:

Lesson concludes with all of us sitting in a circle and discussing not only about the importance of water retention in soil and in sustainable agriculture but about the importance of soil health and the most effective way to protect it as well. Finally, they get as homework research about what is the appropriate crop in each soil with a different degree of water retention.

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

Digital evidence

Documented information: such as notes, photographs, videos, journal written by teacher in lesson flow, presentations, concept maps and comics.

Literature and links

Curell C.,2011. "Why is soil water holding capacity important?". Michigan State University Extension. https://www.canr.msu.edu/news/why_is_soil_water_holding_capacity_important.

Soil experiments FOR CHILDREN. https://www.fao.org/documents/card/en/c/6a170385-0f05-467d-86a6-d736a69be9cf.

Edenhofer, O. et al. in Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (eds Edenhofer, O. et al.) 1–30 (Cambridge Univ. Press, Cambridge, 2014).

Searchinger, T. et al. Creating a Sustainable Food Future. A Menu of Solutions to Sustainably Feed More Than 9 billion People by 2050 (World Resources Institute, Washington, 2014).

Can we create the "perfect" farm? - Brent Loken. https://www.youtube.com/watch?v=xFqecEtdGZ0.

Understanding Our Soil: The Nitrogen Cycle, Fixers, and Fertilizer. https://www.youtube.com/watch?v=A8qTRBc8Bws.

What is Regenerative Agriculture? https://www.youtube.com/watch?v=fSEtiixgRJI.

Agriculture and biodiversity, growing with nature. https://www.youtube.com/watch?v=MkhMkKIppZQ.

Basics of Agroforestry. https://www.youtube.com/watch?v=jLZ0KtNx354.

Industrial biotechnology solutions for sustainable agriculture. https://www.europabio.org/wp-content/uploads/2021/01/2020_01__I_R_Industrial-biotechnology-solutions-for-sustainable-agriculture.pdf

Soil Health essential part of circular bioeconomy. https://www.agro-chemistry.com/news/soil-health-essential-part-of-circular-bioeconomy/

Making comics software**.** https://edtech.gr/make-beliefs-comix/

Making concept maps free program: https://www.canva.com/graphs/concept-maps/

Lesson Plan 4

Subject(s): Science, Biology, Chemistry, Physics, Agriculture, STEM.	**Title of Lesson:** Automated soil moisture control **No. of Lesson 5 of 6**	
Date: Spring term 2024	**Class:** secondary education	**Time:** 12:30-14:00 **Duration:** 1h&30 minutes
BioBeo Theme: Food Loop, Forestry	**Keywords/Phrases:** soil moisture sensor, bioeconomy, sustainable agriculture.	

Learning Outcomes:

By this lesson plan activity, the students will be able to:

1. be informed about how, using technology, can control the soil moisture.
2. learn about using open-source software.
3. calibrate the soil moisture sensor.
4. measure Soil Moisture using either Analog Output or Digital Output.
5. work in groups in a virtual classroom.
6. make electronic circuits.
7. develop critical thinking and research skills by choosing the right function of soil moisture sensor.

Resources/Materials/Equipment:

Arduino Uno R3.

USB 2.0 cable type A/B.

Resistive Soil moisture sensor.

Capacitive Soil moisture sensor

Mini breadboard.

Jumper wires

9V Power adapter for Arduino (optional)

Laptop

Internet connection

arduino.ide software

access to tinker cad virtual classroom

Introduction:

Soil moisture is basically the content of water present in the soil. This can be measured using a soil moisture sensor which consists of two conducting probes that act as a probe. It can measure the moisture content in the soil based on the change in resistance between the two conducting plates.

The resistance between the two conducting plates varies in an inverse manner with the amount of moisture present in the soil[8].

Development:

1. Students read digitally the article about : Digitization in agriculture - from precision farming to farming 4.0. **[5minutes]**
2. Students log in to the tinkercad virtual classroom and familiarize themselves with the tinkercad platform according to the teacher's instruction sheet. **[10 minutes]**

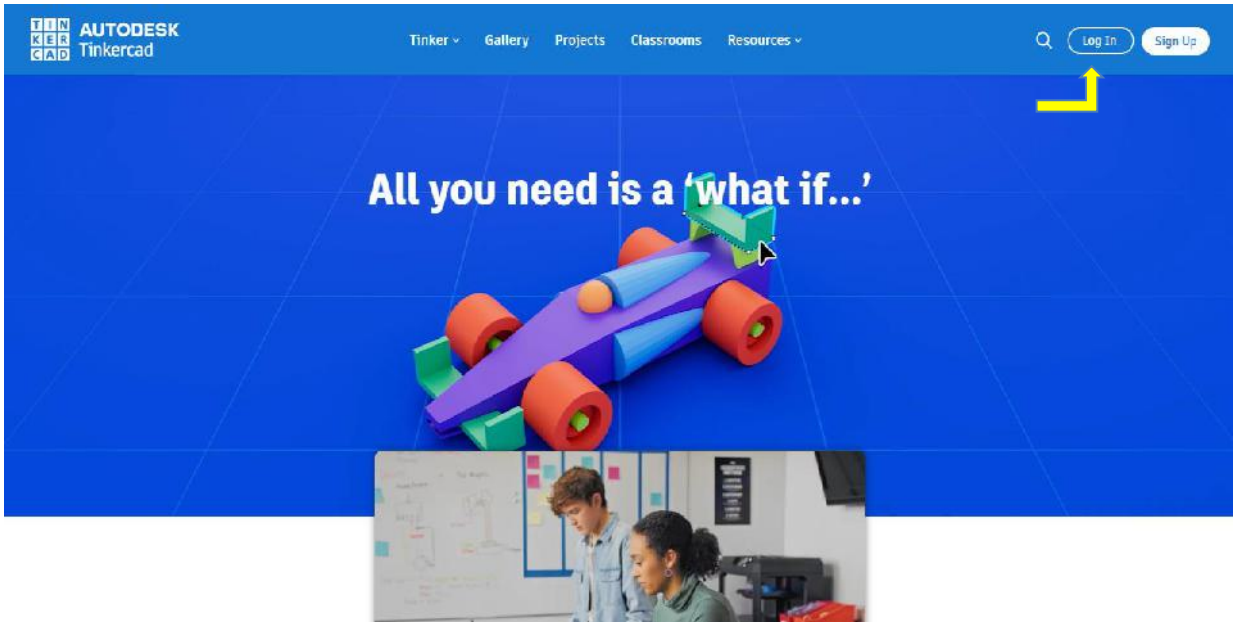


Figure 1: Open page of Tinker Cad platform

[8] https://www.electronicwings.com/arduino/soil-moisture-sensor-interfacing-with-arduino-uno

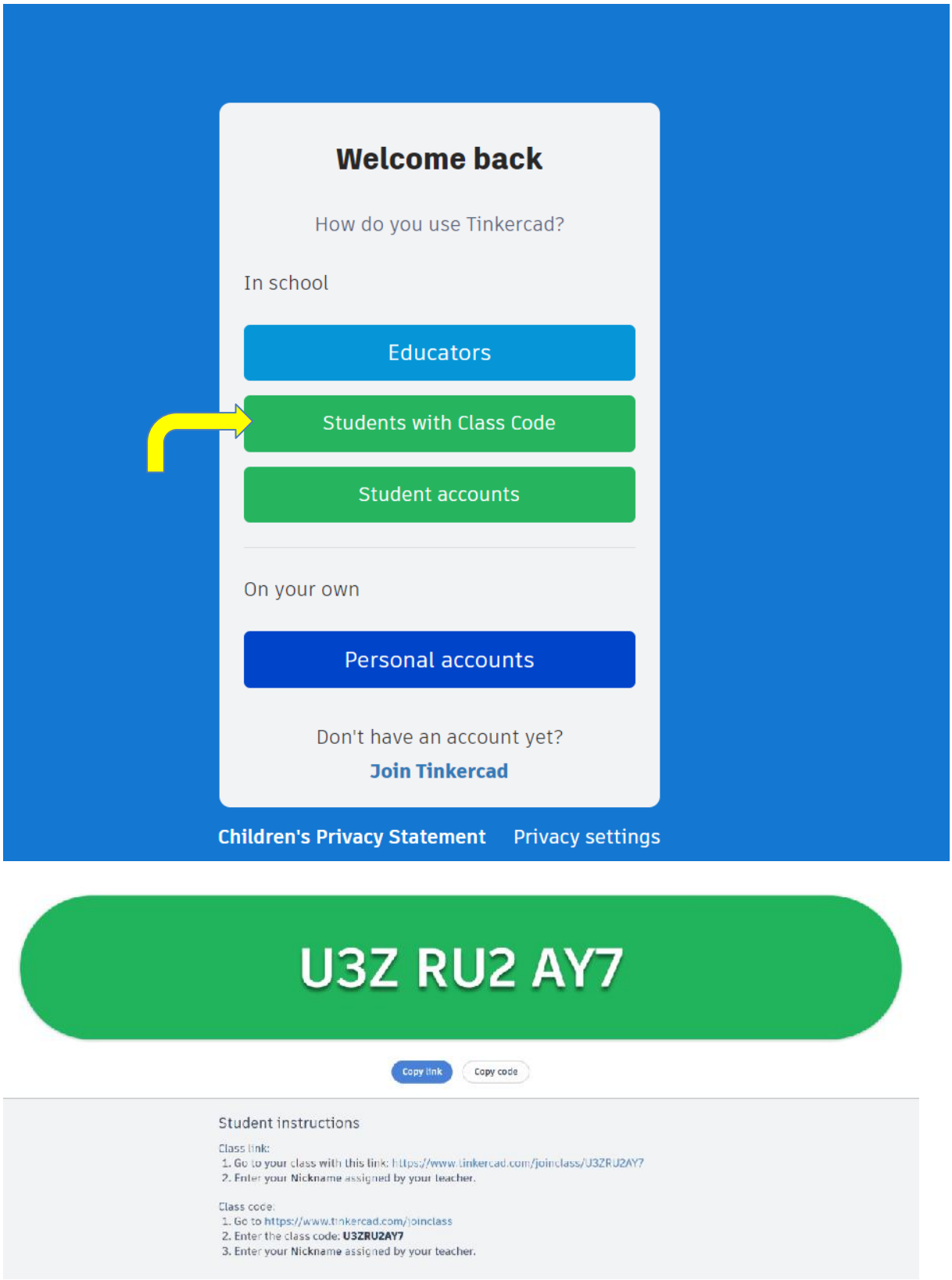


Figure 2 : Log In instruction page to Virtual Class

3. Students install the Arduino.ide on the laptops according to teacher's instructions. **[10minutes]**

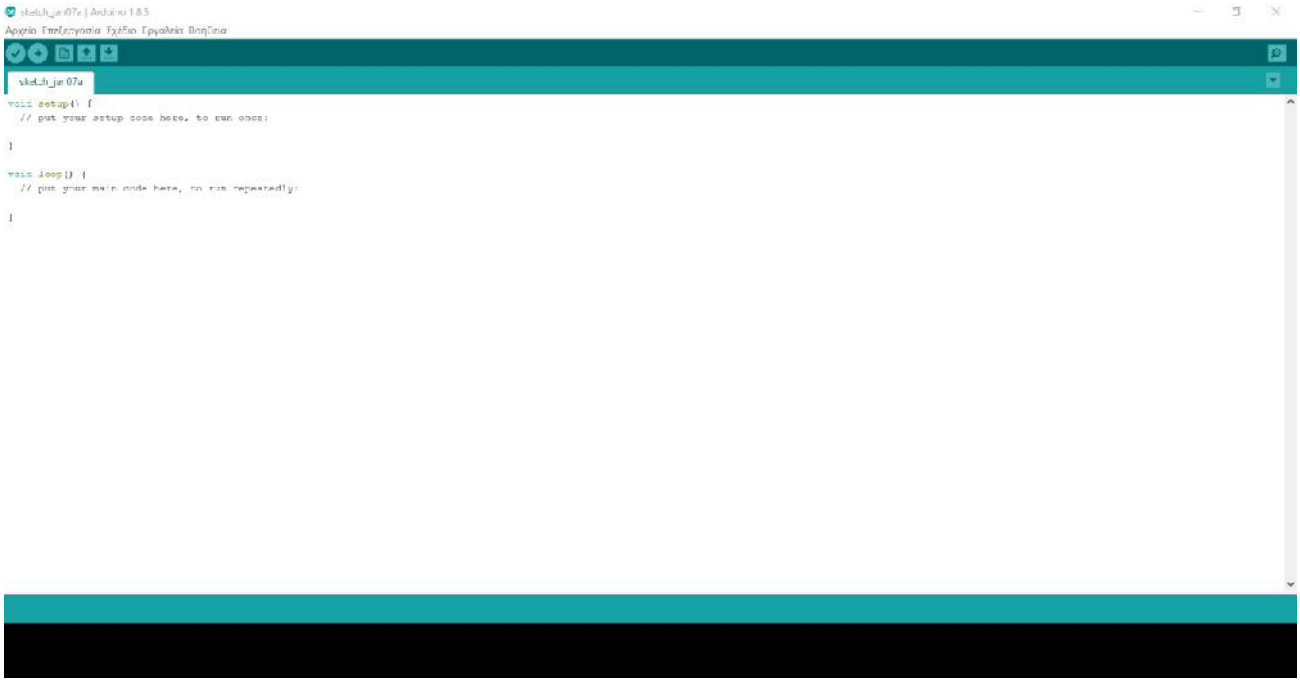


Figure 3: Code Page of arduino

4. Students in groups, according to the teacher's instruction sheet, take all the appropriate equipment for the construction. **[5minutes]**
5. Students in groups, act calibrating, testing the soil sensor, taking notes and finally decide how they will use the sensor for their project. They design and implement the electronic circuit. **[50minutes]**

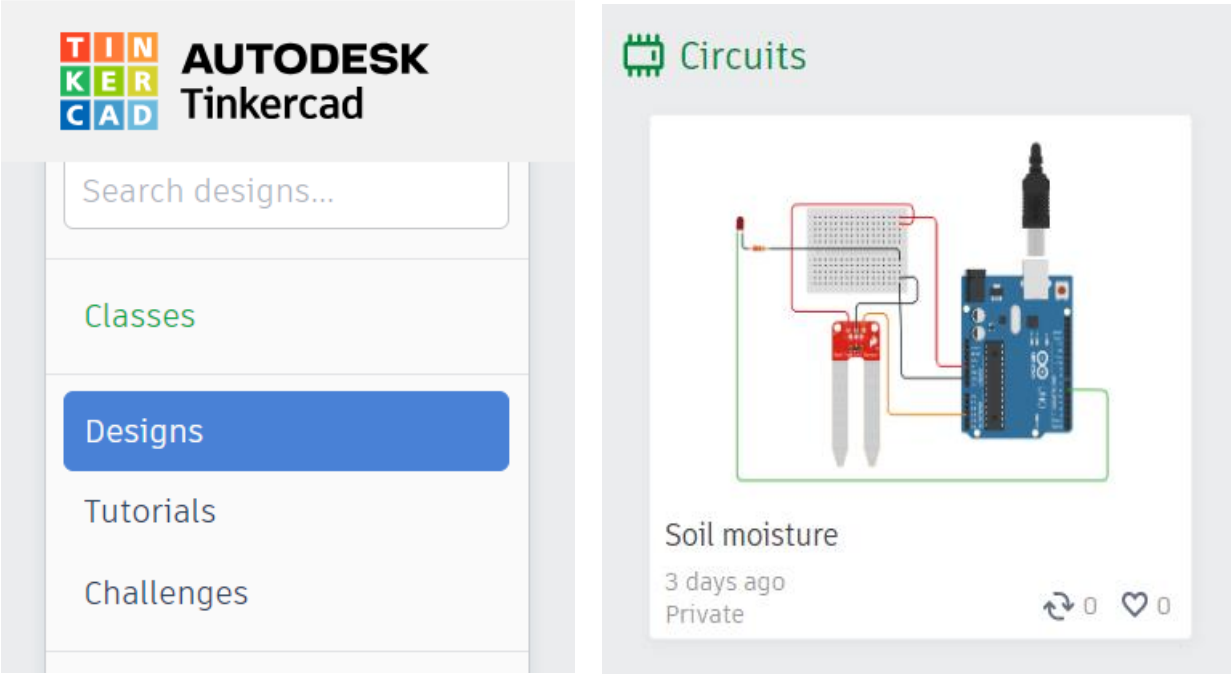


Figure 4: Tinker Cad worksheet path

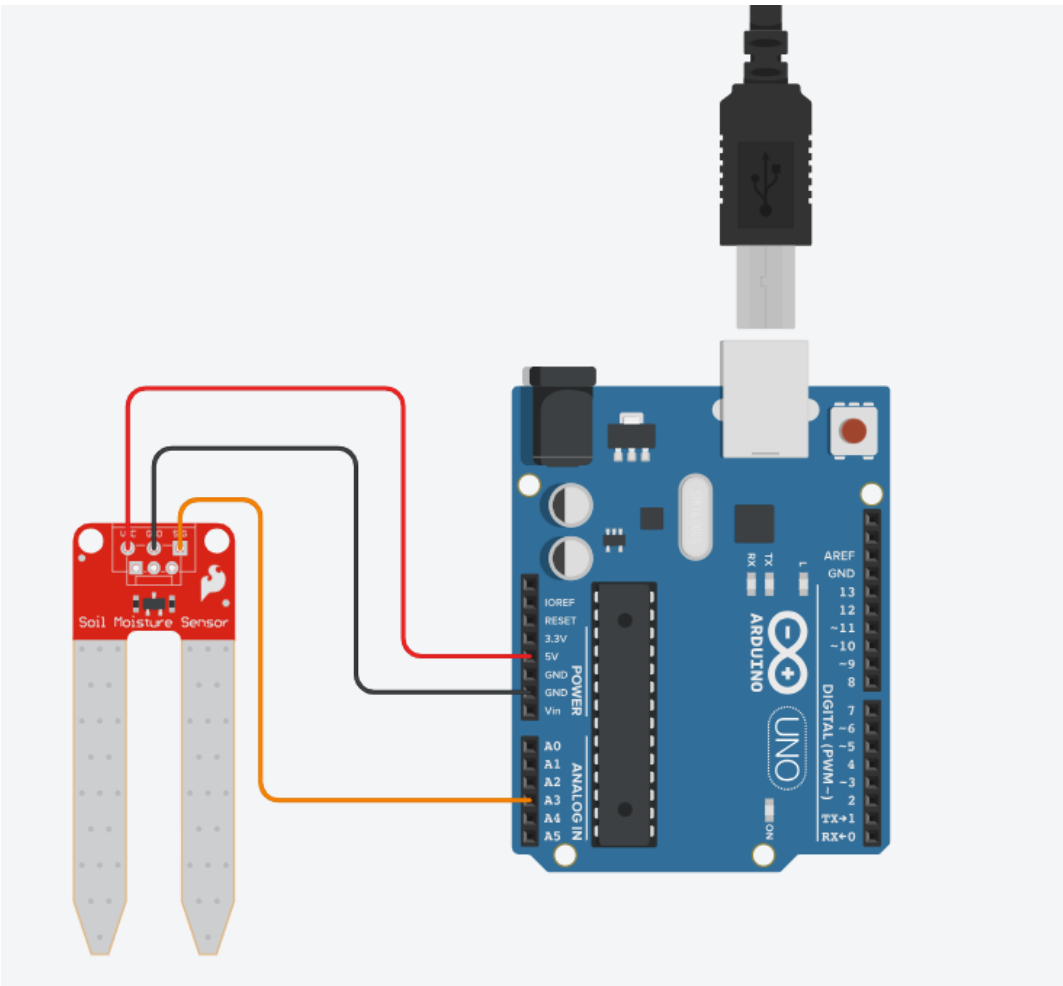


Figure 5: test Sensor circuit diagram

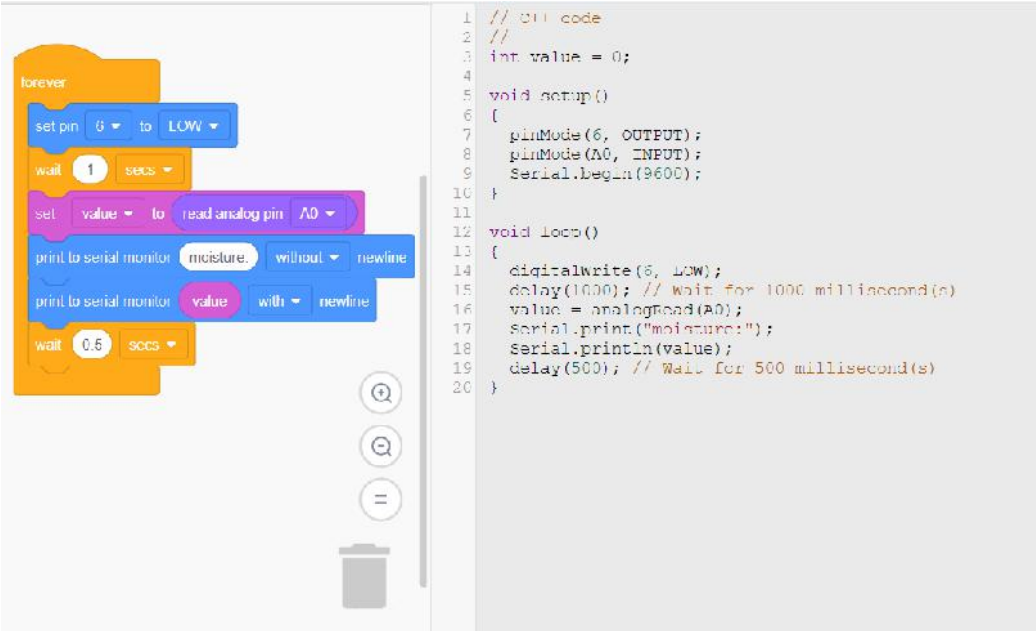


Figure 6: Code Blocks & Code in C++

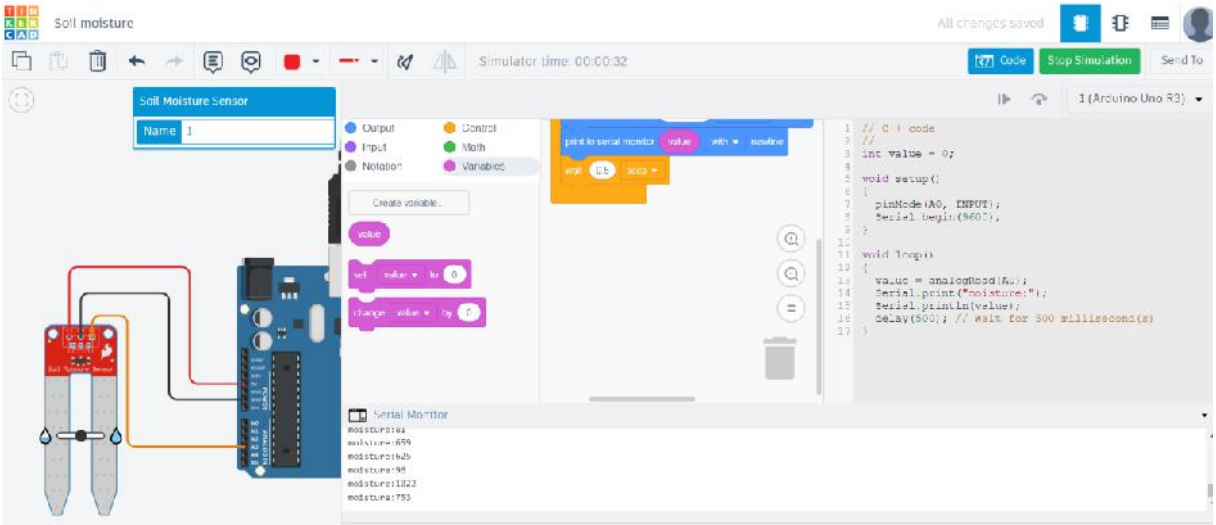


Figure 7: Simulation results

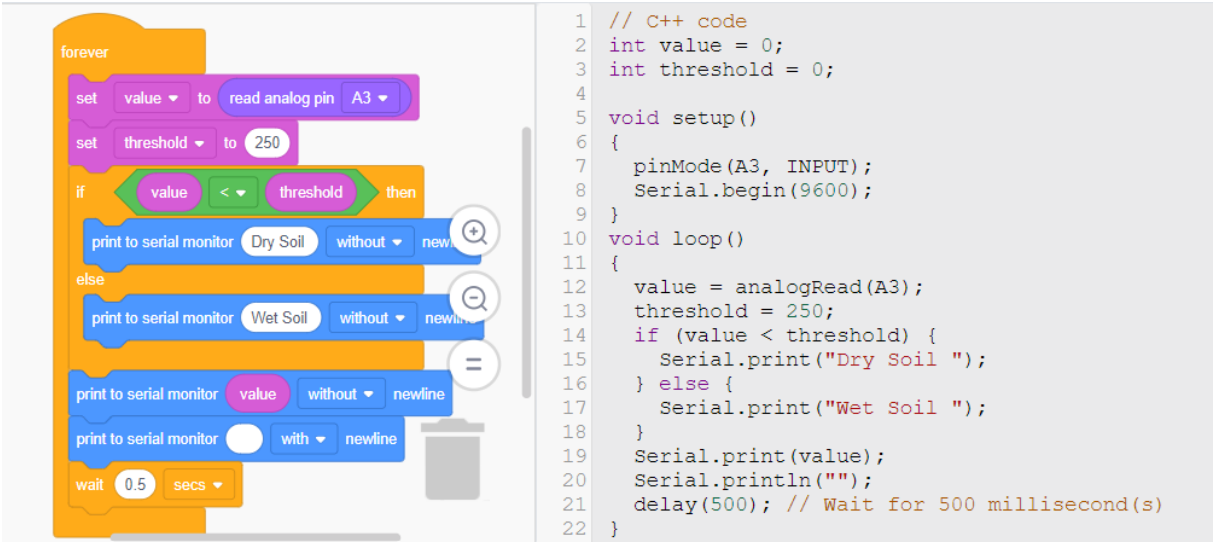


Figure 8 : Moisture sensor Calibration Code

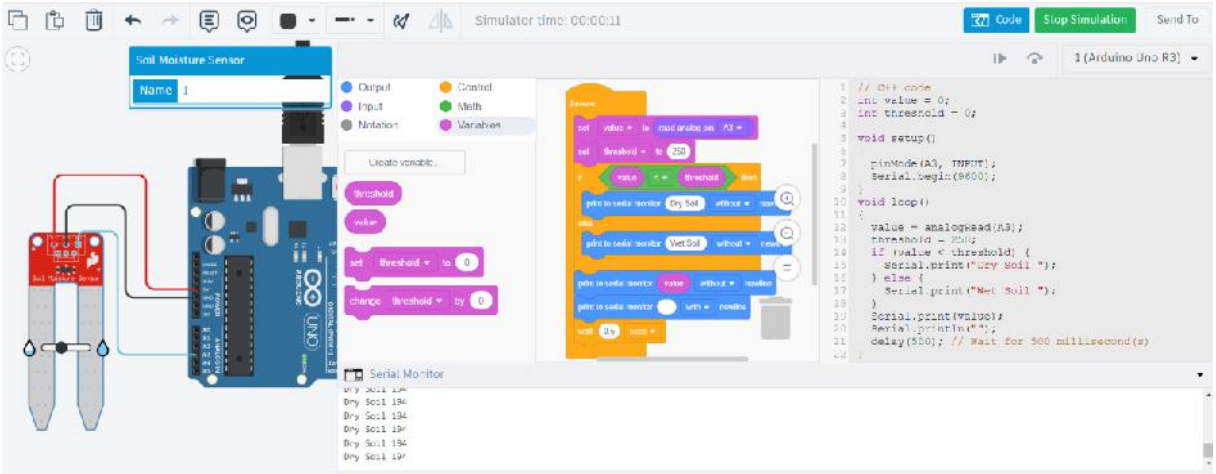


Figure 9a : Calibration results

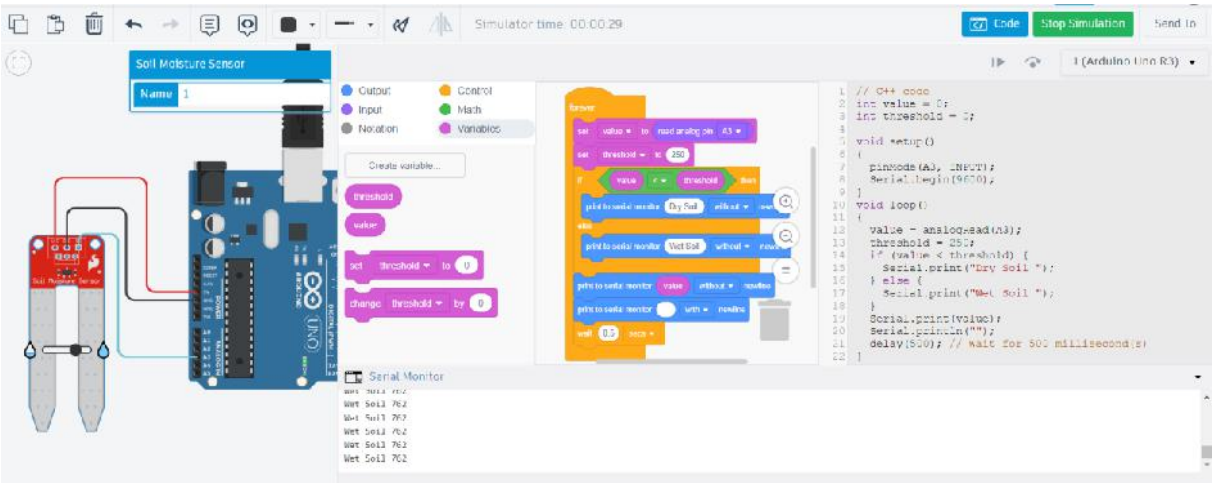


Figure 9b : Calibration results

6. Students in groups make a presentation about their construction, the problems, and the results. **[10 minutes]**.

Conclusion:

Lesson concludes with all of us sitting in a circle discussing the previous presentations.

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

Digital evidence (archives, codes, circuits)

Documented information: such as notes, photographs and learning stories, journal written by teacher in lesson flow, presentations.

Constructions

Literature and links

Digitisation in agriculture - from precision farming to farming 4.0. https://www.biooekonomie-bw.de/en/articles/dossiers/digitisation-in-agriculture-from-precision-farming-to-farming-40.

Arduino – Soil moisture sensor. https://arduinogetstarted.com/tutorials/arduino-soil-moisture-sensor.

Soil Moisture Sensor Interfacing with Arduino UNO. https://www.electronicwings.com/arduino/soil-moisture-sensor-interfacing-with-arduino-uno.

Resistive Soil moisture sensor datasheet. https://www.datasheethub.com/fc-28-soil-moisture-sensor-module/

Grove - Capacitive Moisture Sensor (Corrosion Resistant) datasheet. https://wiki.seeedstudio.com/Grove-Capacitive_Moisture_Sensor-Corrosion-Resistant/

How Soil Moisture Sensor Works and Interface it with Arduino.https://lastminuteengineers.com/soil-moisture-sensor-arduino-tutorial/?utm_content=cmp-true.

Lesson Plan 5

Subject(s): Environmental Sciences, Science, Biology, Chemistry, Physics	**Title of Lesson:** Sustainable forestry and products **No. of Lesson** 1 of 1	
Date: Spring term 2024	**Class:** Secondary Education (14 – 18 years old)	**Time:** 10.00 am – 12.00 pm **Duration:** 2 hours
BioBeo Theme: Forestry	**Keywords/Phrases:** bioeconomy, forests, forest products, sustainable forestry practices.	

Learning Outcomes:

By this lesson plan activity, the students will be able to:

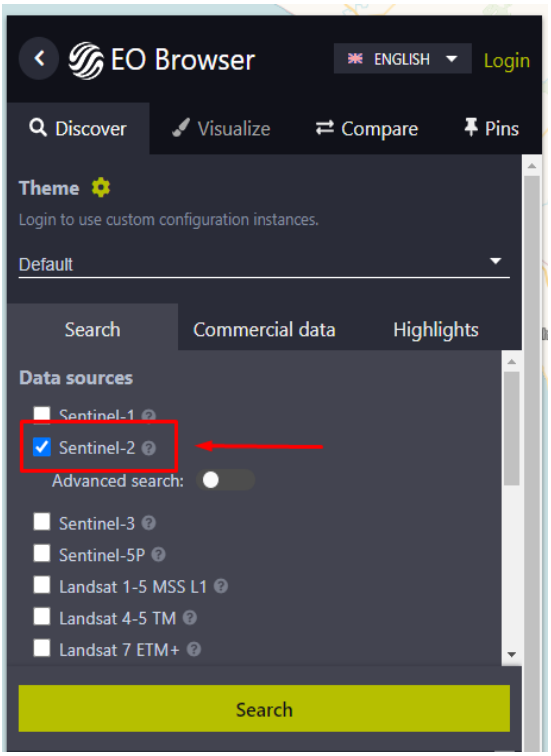
1. Understand the chemistry and production processes of bio-based products.
2. Compare and contrast the advantages and disadvantages of bio-based products with traditional products.
3. Evaluate the potential of bio-based products for sustainability and environmental impact.
4. Analyze different applications of bio-based products and their potential to replace traditional products.
5. Develop critical thinking skills to understand the challenges associated with bio-based products and their commercialization.

Resources/Materials/Equipment:

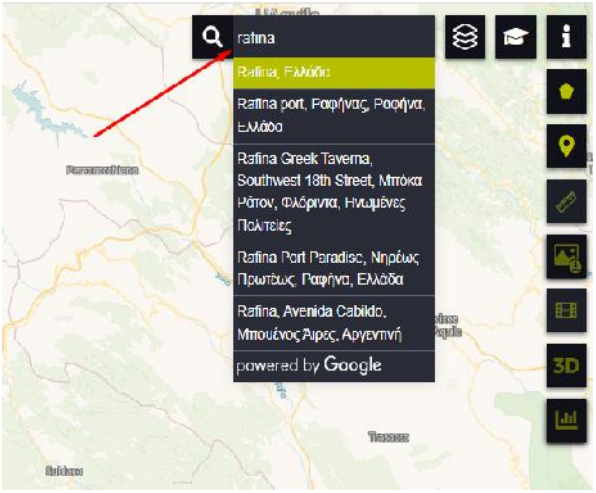
Desktop computer or laptop or tablet
Connection to the Internet

Activity with NDVI index (Step by step procedure):

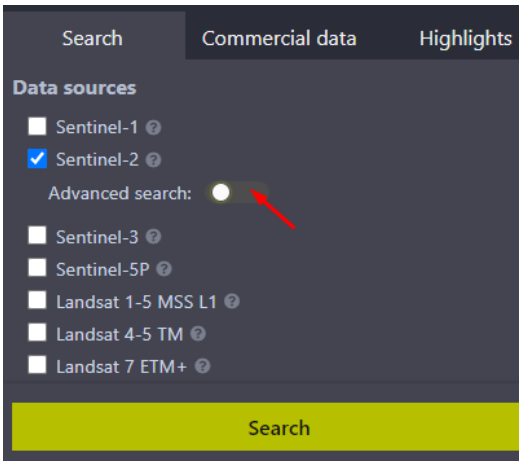
Visit the web page https://apps.sentinel-hub.com/eo-browser and select the Sentinel-2 satellite.



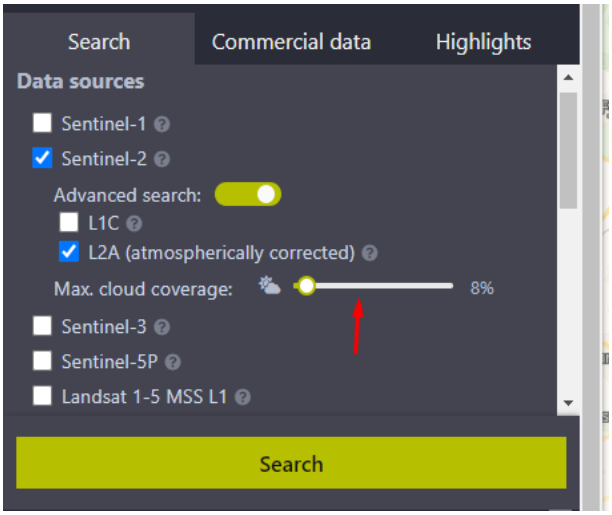
In the Search tool type the word “rafina” and choose from the popup list the town “Rafina, Greece”.



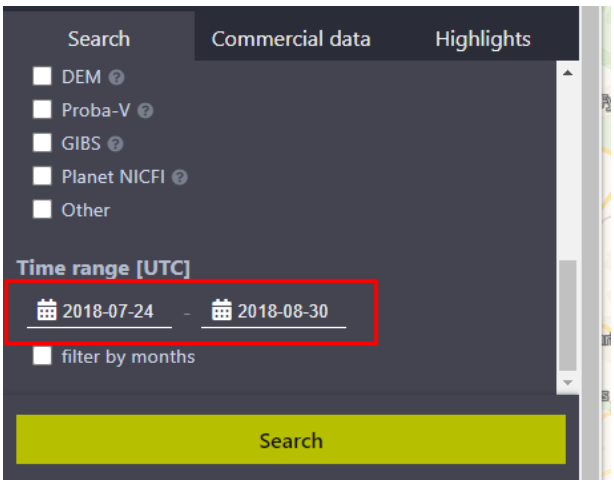
Enable the Advanced search.



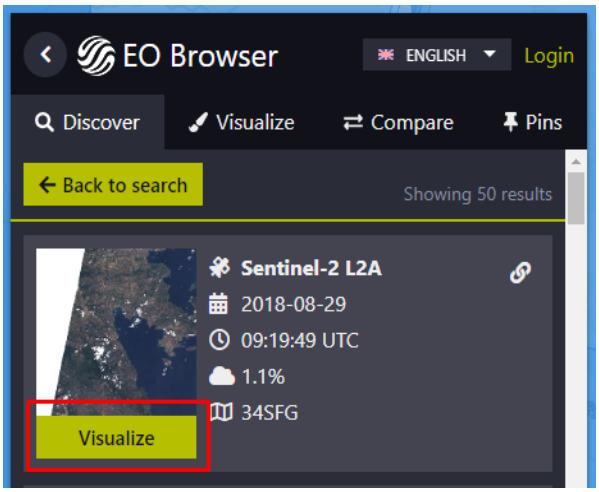
Set the “Max. cloud coverage” to 8%.



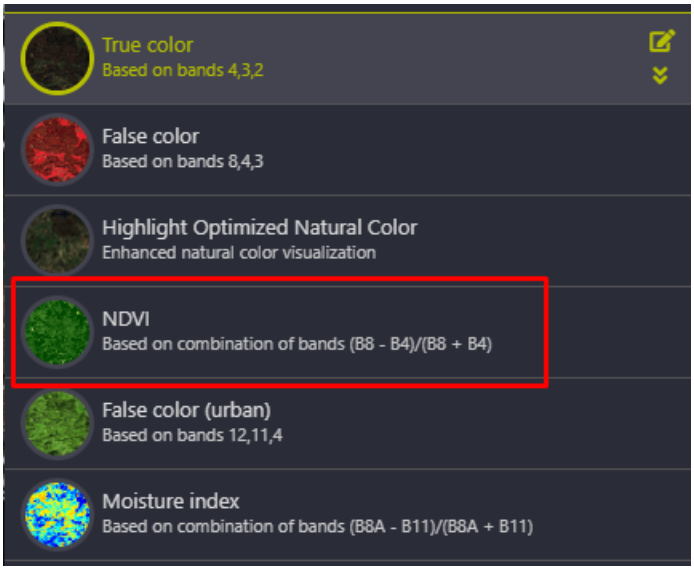
Define the date criteria (as shown in the following picture) and click on the Search button.



From the results list, click the "**Visualize**" button in order to see the image from satellite data.

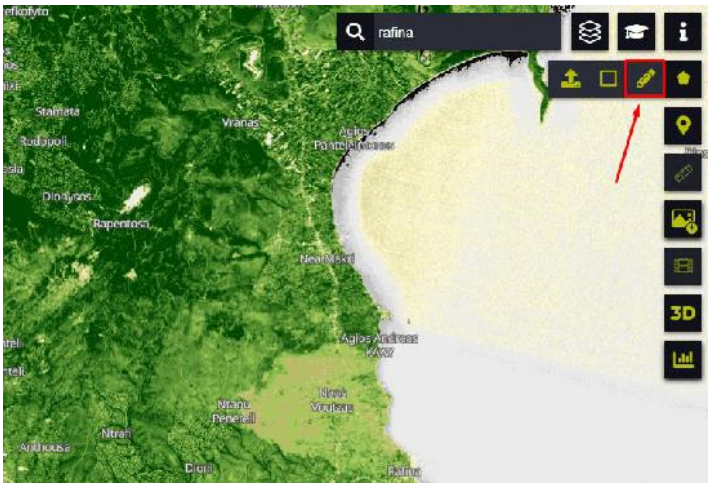


Select the NDVI option to calculate the NDVI index for each pixel of the image previously selected.

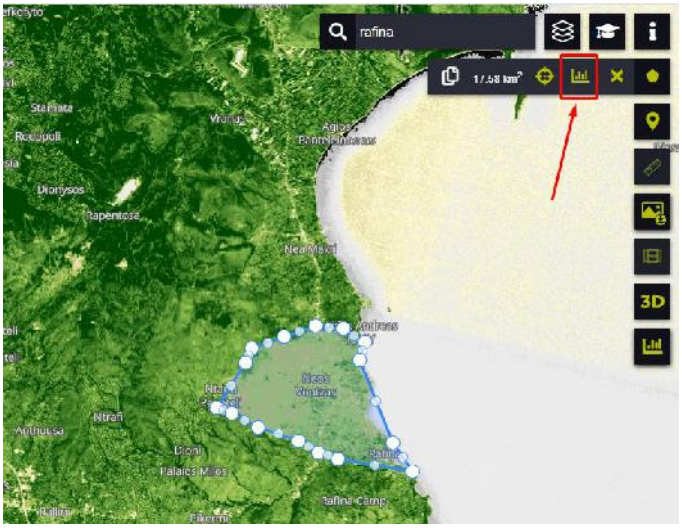


The selected area (with red color line) was burnt in a wildfire of 23-07-2018 where 103 people lost their lives. As you can see the color of this area is different (lighter) from the adjacent areas. This is because the value of NDVI index is almost zero.

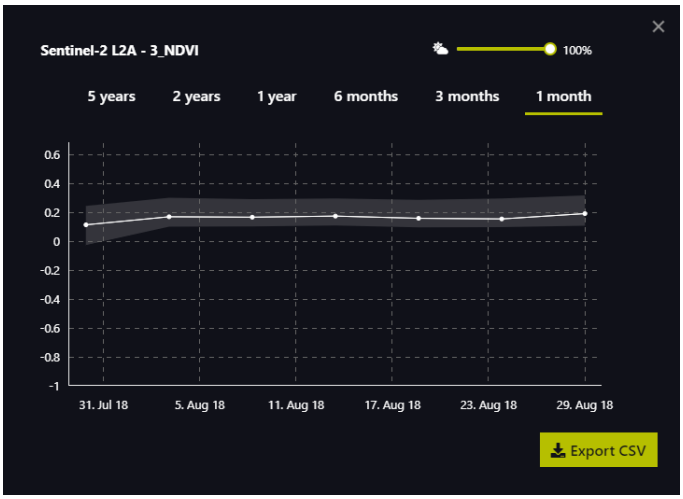
Click on the “Draw polygonal area” tool in order to select the burnt area.



After drawing the polygonal around the burnt area, click on the “Statistical Info” tool to load historical data.

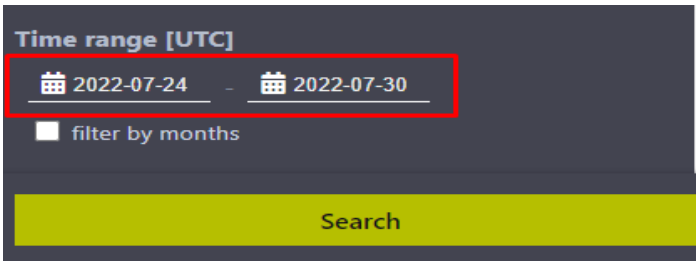


Because the selected area is burnt, the value of NDVI index is almost zero.

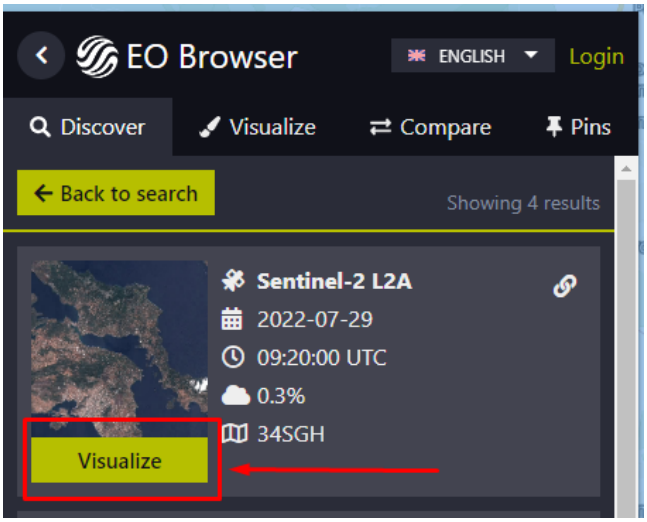


Load statistics for the last 3 months. If you study the chart carefully you will see that in July 2018 the price of the index drops sharply. This is due to the fact that the entire area has been burned.

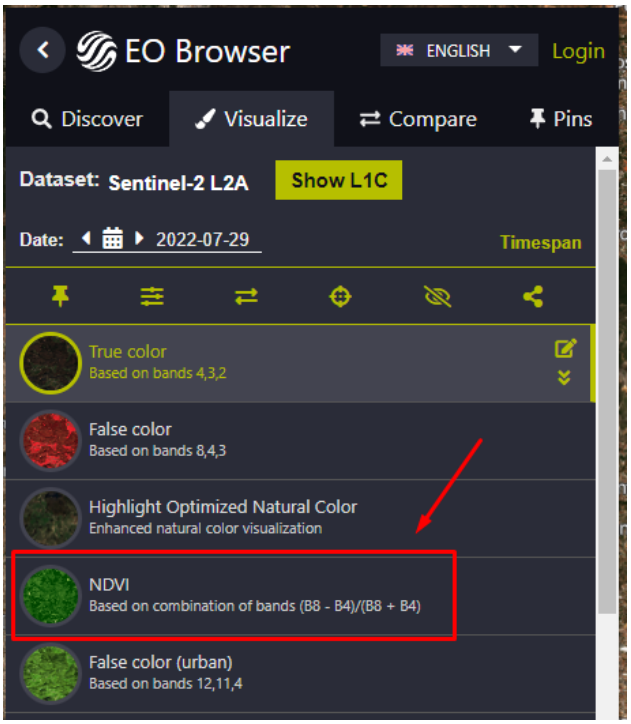
Change the date criteria and search again in order to find recent pictures of the burnt area.



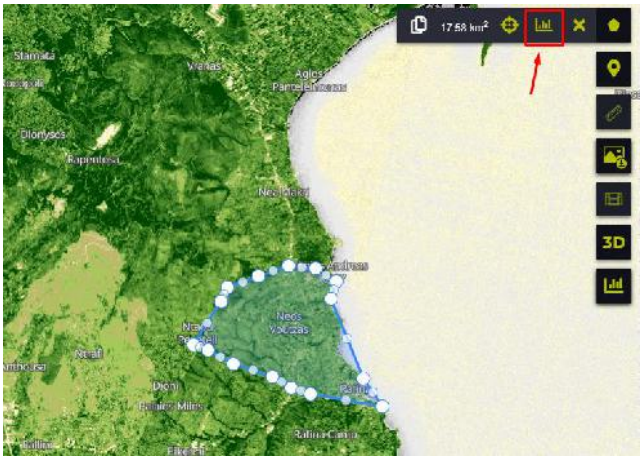
From the results list, click the "**Visualize**" button in order to see the image from satellite data.



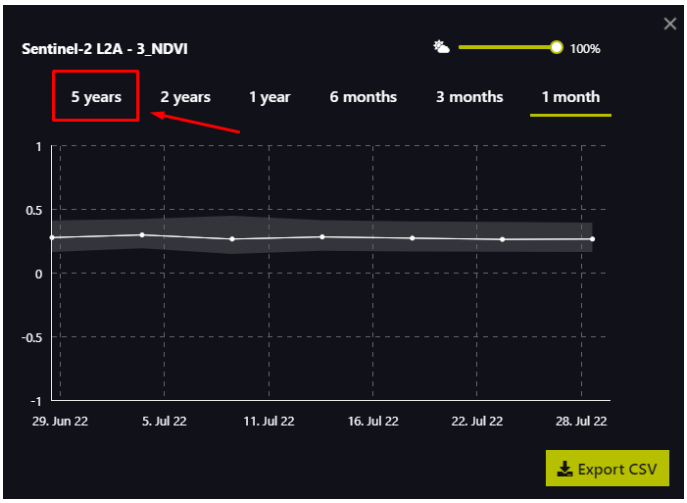
Select the NDVI option to calculate the NDVI index for each pixel of the image previously selected.



The burnt area is already selected. Click on the “Statistical Info” tool to load historical data.



Load historical data for the 5 previous years.



Change the “Cloud coverage” parameter to 5%, so images with clouds are not included in the statistical data.

As you can notice in the graph in the summer of 2018 we had a sharp drop due to the fire and as the years go by the value of the NDVI index has an upward trend which means that part of the forest that was burned is refosterated.

Introduction:

Forestry is part of the bioeconomy on various levels. European forests and the forest sector have the opportunity to take a leading role in the sustainable development of a circular bioeconomy. The forest-based bioeconomy provides millions of jobs and relies on wood and non-wood materials for sustainably sourced bio-based products and renewable energy. At the same time, it maintains livelihoods and a plethora of regulating and cultural ecosystem services, ultimately contributing to climate change mitigation and a sustainable future.

Development:

1. Brainstorming / Discuss the benefits of healthy forests, such as providing clean air and water, habitat for wildlife, and carbon sequestration. **[5 minutes]**

   Raise the interest of students; try to integrate students by questioning them/asking them **if they know products produced in forests.**

2. Discuss the different types of forest products, such as food, medicine, and materials for construction.
   [5 minutes]

3. Search for reports from the **World Food & Agriculture Organization (https://www.fao.org/home/en)** on forest products produced annually. **[5 minutes]**

   The teacher divides the class in groups of 3 or 4 students.

   Each group does a little internet research on forest products produced annually.

4. Ask students to research and write a paragraph about one **forest product** and its uses. **[15 minutes]**

   Each group does a little internet research and writes a paragraph about one forest product and its uses.

5. Study of areas of the planet that are being deforested for other activities using **Google Earth's Changing Forests** module https://earth.google.com/web/@-16.78379398,-62.79654238,268a,71892d,35y,-17h,59t,0r/data=Ci4SLBIgZjZlNDgwYTM0Njk3MTFlYWE3MWIyZGUyNWIyYWZmNjkiCHNveWJlYW5z
   [45 minutes]

   Students study the **Changing Forests section of Google Earth** and document the causes of deforestation.

   Each group has to make a **presentation** on the subject to the class.

6. Students learn how they can monitor vegetation using satellite data from ESA's Sentinel satellites and then choose a forest area close to their town to monitor and inform the local government of changes taking place (e.g. deforestation, fires) so that timely measures are taken to protect these forest areas.
[30 minutes]

   Students do the **Activity with NDVI index** (Resources/Materials/Equipment) and then apply this knowledge to a forest area near their city.

7. Students learn about the EU policy about forests (https://environment.ec.europa.eu/topics/forests_en).
[15 minutes]

   Students in groups study the **EU Policies about forestry** and document the policies and actions that have been taken by the EU.

Conclusion:

We divide the class into 17 groups (some students may be left alone). We have also prepared 17 cards with numbers from 1 to 17. Each team chooses a card at random. The 17 numbers correspond to the United Nations' 17 Sustainable Development Goals (SDGs) .

Each team has 5 minutes to connect the forestry to the SDG goal of the card they chose (if possible). At the end, each group presents its opinion to the plenary.

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

Digital photographic evidence/ IPad or class camera in use.
Documented information: such as notes, photographs, videos, and learning stories, journal written by teacher in lesson flow.
Art works produced by children (co-researchers) and photos of processes.
Pupils' self-assessment: completing their learning surveys and follow on learning with class teacher and parents in the week between each lesson.

Literature and links

Sustainable forestry: Parliament's work to fight deforestation. https://www.europarl.europa.eu/news/en/headlines/eu-affairs/20201015STO89416/sustainable-forestry-parliament-s-work-to-fight-deforestation

European Commision - Forests. Improving the quality and quantity of EU forests and strengthening their protection, restoration and resilience. https://environment.ec.europa.eu/topics/forests_en

Europe's forest sector. https://forest.eea.europa.eu/topics/forest-bioeconomy/introduction

ESA Eduspace. https://www.esa.int/SPECIALS/Eduspace_EN/SEM7IQ3Z2OF_0.html

CERTI: Remote sensing for monitoring vegetation. https://certi.org.br/blog/en/remote-sensing-for-monitoring-vegetation/

Lesson Plan 6

Subject(s): Science, Biology, Chemistry, Physics, Agriculture	**Title of Lesson:** Let's have a Bio-Beo Party **No. of Lesson 6 of 6**	
Date: Spring term 2024	**Class:** Secondary Education	**Time: flexible** **Duration: 2h**
BioBeo Theme: Food Loop, Forestry, Interconnectedness, Outdoor learning	**Keywords/Phrases:** circular economy, sustainable agriculture, environmental pollution**.**	

Learning Outcomes:

1. learn about soil and the importance of being healthy.

2. learn about sustainability.

3. develop critical thinking and research skills by taking part in all the previous activities.

4. develop communication skills by presenting their job in the school festival.

Resources/Materials/Equipment:

Laptop

Internet connection

Archives and constructions from previous lessons

Making video free software

Introduction:

A very important step for sustainable development is not only to inform ourselves about it but also to communicate our knowledge to others.

Parental engagement before implementation

Set clear goals.

At the commencement of the workshop, the designated instructors summon parents and provide an initial overview of the workshop's structure and activities. Subsequently, a comprehensive presentation unfolds on the foundational principles of Bioeconomy, elucidating its pivotal role in the global economy. This presentation underscores how a subtle alteration in a family's daily routines, encompassing aspects ranging from the quality of consumed food to waste management practices, can actively contribute to the establishment of a sustainable future and foster the cultivation of conscientious citizens. Instructors earnestly encourage parental involvement in this alternative educational paradigm, either through participation in select activities during workshop hours, leveraging relevant expertise, or through the facilitation of their children's preparatory efforts for

activities beyond the workshop schedule. In conclusion, instructors solicit parental input for the school celebration event, wherein students will articulate the outcomes of their collective endeavors.

Organize a plant exploration in Agricultural University or Botanical Garden or a large plant nursery.

A visit to a Botanical Garden would be beneficial, as students, accompanied by their parents, could photograph plants, observe the soil in which they are planted, and learn about their requirements, potential diseases, and benefits from informative labels. In the case of a visit to a plant nursery, it would be possible to gather the aforementioned information from the nursery's agricultural specialist.

Research about the manner of creating recycled products.

In preparation for the invitations for the school festival, students, along with their parents based on their assigned groups, explore sustainable methods online. They are researching either for the creation of recyclable paper to write the invitations or to produce natural ink, which can be used for writing the invitations (e.g., ink from squid, dye from beets). This initiative combines creativity and sustainability, showcasing the students' efforts to create eco-friendly invitations for the school festival. At the end of the festival both families and teachers' plant in a little pot their invitation. The seeds in it in a few days start to grow in an aromatic herb. They made a long-lasting memory.

Development:

Students collect all the materials from previous lessons to make a video telling us about their experiences during this knowledge trip**.**

Parental engagement during implementation

Making a plant power card game

With the assistance of their parents, students will conduct a small research project on the therapeutic properties of the chosen plants. They will gather all the information and input it into a spreadsheet, creating digital cards for each plant. Each plant will correspond to a card containing details such as a plant photograph, name, country/region of origin, soil type, temperature, humidity, therapeutic or cosmetic properties, diseases, etc. These cards will be printed on paper, and during the school festival, parents and children can engage in a card game.

Making recycled paper with seeds - A lifelong memory

Parents and students at work! According to their previous research, some groups are responsible for the creation of recycled paper with seeds in different natural colors and some groups are the natural ink creators according to the following instructions:

plantable seed paper: https://www.countryfile.com/how-to/crafts/make-seed-paper

https://www.abc.net.au/gardening/how-to/diy-seed-paper/9548326.

natural ink: https://www.nps.gov/articles/ink-activity.htm

https://www.thoughtco.com/easy-ink-recipes-3975972

natural paper colorificants: https://midogguide.com/el/diseases/is-stamp-ink-safe-for-dog-paws.html

They prepare the plantable invitations.

Conclusion:

Lesson concludes with students presenting their project to other students at the school.

Parental engagement after implementation

During the school festival, after the children's presentations are completed, students, teachers, and parents engage in impression discussion groups. They also participate in games such as escape rooms and card games that they have created themselves. At the end of the school celebration, students, parents, and teachers plant their invitations in plastic pots/bags made from potatoes, during the workshop. The most sustainable keepsake!

Reflection on Teaching & Learning:

Reflective journal of teacher: Teacher will write down any important statements or key observations of and by the children, learning as the lesson progresses and as the children are in the flow of their tasks and learning experiences. Teacher also reflects on any works e.g. children's drawings, and feedback to teacher questioning/ think-pair-share activities.

Teacher will answer the questions in journalling after: What did the children do? How did they respond? What were the key questions they asked of the lesson? What works did they produce?

Assessment for Learning:

Digital evidence

Documented information: such as notes, photographs and learning stories, journal written by teacher in lesson flow, presentations, videos.

Constructions

Questionnaire for Parents

Dear parents, thank you for taking the time to complete this questionnaire. We are interested in hearing your feedback on the "From satellite to Soil - Sustainable Agriculture " educational scenario. Your responses will help us to improve the activity for future students and parents. The questionnaire should take approximately 10 minutes to complete. All your responses will be anonymous and will be used for improvement. Here is the questionnaire:

(Please indicate your level of agreement with each statement using the following scale: 1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, 5 - Strongly Agree)

Activity Feedback

1. A visit to a Botanical Garden would be beneficial because it allows students and parents to photograph plants, observe the soil in which they are planted, and learn about their requirements, potential diseases, and benefits. [1 2 3 4 5].

2. In the case of a visit to a plant nursery, obtaining information from the nursery's agronomist could enhance the educational experience. [1 2 3 4 5]
3. Learning about plant requirements, diseases, and benefits is an important aspect of a botanical educational visit. [1 2 3 4 5]
4. The opportunity to observe and photograph plants in a botanical setting enhances the educational value of the visit. [1 2 3 4 5]
5. A visit to a botanical garden or plant nursery is a valuable experiential learning opportunity for students and parents. [1 2 3 4 5]

Further Use of Knowledge

6. How do you think the role of soil in storing carbon, water, and nutrients impacts environmental and human health?
7. In your opinion, what are the key challenges posed by climate change that could be addressed through sustainable soil management practices?
8. Reflecting on the narrative, how can the circular bioeconomy contribute to more sustainable waste management, specifically in terms of biodegradable plastics and bio-waste.
9. Considering the disparities in the governance of forestry activities globally, what measures do you think could be taken to promote more equitable and sustainable forestry practices?
10. What role do you see biological raw materials playing in the development of sustainable products, and how can this transformation positively impact our everyday lives?
11. To what extent do you believe biodegradable plastics can contribute to reducing environmental impact compared to conventional plastics? Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree
12. In your experience or understanding, how can parental engagement activities, such as those proposed by this educational scenario, contribute to a more holistic and sustainable education for students?
    Not Effective at All | Slightly Effective | Moderately Effective | Very Effective | Extremely Effective

Additional Questions

(Please indicate your level of satisfaction with each statement using the following scale: 1 - Very Dissatisfied, 2 - Dissatisfied, 3 - Neutral, 4 - Satisfied, 5 - Very Satisfied) when is needed else please answer briefly:

13. I appreciate the effort made by students, teachers, and parents to incorporate sustainability into the school festival activities. [1 2 3 4 5]
14. The escape rooms and card games created by students, teachers, and parents added a fun and engaging element to the school festival. [1 2 3 4 5]
15. The hands-on workshop where invitations were created from recycled materials and planted as keepsakes was an innovative and sustainable activity. [1 2 3 4 5]
16. The overall organization of the school festival, including the interactive activities and discussions, met my expectations for a sustainable and enjoyable event. [1 2 3 4 5]
17. Considering the hands-on workshop where invitations were made from recycled materials and planted as keepsakes, do you believe this type of activity has a lasting impact on raising awareness about sustainability? Why or why not? [1 2 3 4 5]

18. In your opinion, how can future school events incorporate even more sustainable practices? Are there specific suggestions you have for enhancing the eco-friendly aspects of such activities? [1 2 3 4 5]
19. How much time did you spend participating in the activity with your child? (Less than 30 minutes, 30-60 minutes, more than 60 minutes).
20. Did you enjoy participating in the activity with your child? (Yes, No, not sure).
21. Would you be interested in participating in other similar activities with your child in the future? (Yes, No, not sure).
22. Do you have any suggestions for how we can improve this activity in the future?

Literature and links

Making video free software**.** www.flexclip.com

plantable seed paper: https://www.countryfile.com/how-to/crafts/make-seed-paper

https://www.abc.net.au/gardening/how-to/diy-seed-paper/9548326.

natural ink: https://www.nps.gov/articles/ink-activity.htm

https://www.thoughtco.com/easy-ink-recipes-3975972

natural paper colorificants: https://midogguide.com/el/diseases/is-stamp-ink-safe-for-dog-paws.html

National Curricula and Policy/SDG Connections:

The lesson relates to the SDG 8, 12, 13, 15 and 17. Goal 8 is about promoting inclusive and sustainable economic growth, employment and decent work for all[9].

Goal 12 is about ensuring sustainable consumption and production patterns, which is key to sustain the livelihoods of current and future generations[10].

Goal 13 is about climate change. Climate change is caused by human activities and threatens life on earth as we know it. With rising greenhouse gas emissions, climate change is occurring at rates much faster than anticipated. Its impacts can be devastating and include extreme and changing weather patterns and rising sea levels[11].

Goal 15 is about conserving life on land. It is to protect and restore terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and stop biodiversity loss[12].

Goal 17 is about revitalizing the global partnership for sustainable development. The 2030 Agenda is universal and calls for action by all countries – developed and developing – to ensure no one is left behind. It requires partnerships between governments, the private sector, and civil society[13].

The lesson can be applied to the Skills Labs module in Secondary Education (ages 14-18). The Skills Labs is a new, innovative school module which focuses on the cultivation of soft and digital skills. The Skills Labs' main goal is the cultivation of skills necessary for a rapidly changing world. These skills include both fundamental life skills related to health, safety, and social interactions, as well as more elaborate skills related to education and life-long learning. Emphasis is placed on the **4Cs of 21st century skills – communication, collaboration, critical thinking, and creativity – along with digital skills.** The Skills Labs is designed to promote and bring into effect the **UN Sustainable Development Goals, with particular emphasis to Goal 4.7** and has gathered significant attention from international bodies such as UNESCO. It was awarded the **Global Education Network Europe (GENE) Global Education Award (2020/2021)**[14].

[9] https://www.un.org/sustainabledevelopment/economic-growth/
[10] https://www.un.org/sustainabledevelopment/sustainable-consumption-production/
[11] https://www.un.org/sustainabledevelopment/climate-change/
[12] https://www.un.org/sustainabledevelopment/biodiversity/
[13] https://www.un.org/sustainabledevelopment/globalpartnerships/
[14] https://eurydice.eacea.ec.europa.eu/news/greece-21st-century-skills-labs-ergastiria-dexiotiton