European Commission

NATURE-BASED SOLUTIONS LEARNING SCENARIO

Water Management at Urban Areas

Research and Innovation

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European Commission

Directorate-General for Research and Innovation

Healthy Planet – C3 - Climate and Planetary Boundaries

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Contact Josefina ENFEDAQUE

Email josefina.enfedaque@ec.europa.eu

RTD-PUBLICATIONS@ec.europa.eu

European Commission

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NATURE-BASED SOLUTIONS LEARNING SCENARIO

Water Management at Urban Areas

Jose Manuel Viñas Diéguez

Directorate-General for Research and Innovation

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ABSTRACT

This learning scenario encourages students to learn and care about the importance of water management to tackle urban challenges such as floods and disruption of the water cycle in the urban environment via nature-based solutions (NBS). Through the activities, students will work as scientists following the approach of Inquiry-based learning by following the design process as engineers (or landscape architects). The main topic discussed will be based on the case study "Cloudburst Management Plan, Copenhagen" from <https://oppla.eu/casestudy/18017>.

Keywords
Water-management, evapotranspiration, infiltration, water-storage, nature-based solutions

1. Introduction

> *"Nature-based solutions (NBS) are solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services."*
> *https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en*

To use this Learning Scenario more effectively, teachers are encouraged to:

- Check out the list of recent EU publications on Nature-Based solutions
- Read about Nature-based solutions: Transforming cities, enhancing well-being (also available as a PDF)
- Contact local NBS practitioners or scientists working in their area (they can be found through Oppla).
- Use the "Ask Oppla" service to request help in case of any technical/scientific question on NBS.

2. Overview

Overview	
Subject	Biology & Geology, Earth Sciences, Geography
Topic	Water management
Age of students	12–13 years old
Preparation time	2 hrs
Teaching time	250 min. including 2 explanation (35') video classes
Online teaching material	Video Water management: https://youtu.be/pavtjtggffu Platforms and tools: Students can be connected with the teacher through online meeting tools.
Offline teaching material	For the evapotranspiration activity the following materials are needed: • 1 plant, in 10 cm containers. • 2-liter plastic bottles • Scale, accurate to 0.1 gram • 2 stopwatches or timers • Calculators • Blue dish

Overview	
	• Pencils, coloured pencils or markers, ruler (for graphing). To improve infiltration and storage capacities each student needs: • 30 cm biodegradable coir hanging basket or planter • 5-liter bucket, to catch draining water • Chronometer • Measuring cup, volumetric cylinder, or some other graduated plastic container, for measuring water volume For the "Best media matter to improve infiltration and storage capacities" Worksheet, one per student: • 2 kg bag construction/playground sand • 2 kg bag soil compost • 2 kg bag pea gravel • 0.5 kg bag harvested hardwood mulch
NBS resources used	• Example of an Oppla case of study: Cloudburst Management Plan, Copenhagen • The United Nations World Water Development Report 2018: Nature-Based Solutions for Water. Paris, UNESCO. Available at: http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/2018-nature-based-solutions/ • Green Infrastructure Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects. 2014 United Nations Environment Programme Agency. Available at: http://www.unepdhi.org/-/media/microsite_unepdhi/publications/documents/unep/web-unep-dhigroup-green-infrastructure-guide-en-20140814.pdf • Environment, Land, Water and Planning. Planning a Green-Blue City. February 2017. Australia. Available at: https://www.water.vic.gov.au/__data/assets/pdf_file/0029/89606/Green-blue-Infrastructure-Guidelines-Feb17.pdf Extra resources that teachers may want to use: • Water in Cities - https://youtu.be/ImzNmJT3_OA • An Intro to Urban Wastewater Systems - https://youtu.be/-HkRkCXPjzw • Nature-based solutions for flood mitigation and coastal resilience • Nature-based solutions improving water quality & waterbody conditions

3. Integration into the curriculum

NBS aim to tackle environmental and social challenges. Learning about multipurpose NBS could, therefore, fall in under strands of learning mentioned in the curriculum. The topic of water management suits particularly well with these two standard fields mentioned by The Spanish curriculum:

- Understanding and identifying the meaning of sustainable water management and developing actions that contribute to that management.
- Recognising water pollution problems.

This LS can be implemented, collaboratively, by a group of teachers from different subjects.

4. **Aim of the lesson.**

- Teach students about the concept of NBS and how to assess the value of the initiative and/or plant for their local environment and biosphere.
- Provide students with information and raise awareness about the relevance and essential role of water management in an urban area for the environment, biodiversity, health and wellbeing of the local population, social justice, and urban planning.
- Allow students to relate cause and effect relationships: that could be used to predict phenomena in natural or designed systems.

5. **Outcome of the lesson**

Beyond the aims of the lesson, students will also be able to understand concepts such as infiltration, evapotranspiration, and water storage, in addition to the complexity of water management in urban areas.

6. **Trends**

Project-based learning and Design thinking, collaborative learning, outdoor education.

7. **21st-century skills**

Critical thinking, collaboration, communication, leadership and productivity, civic awareness.

8. **Activities**

Name of activity	Procedure	Time
Activity 1		
1a. Introduction. Water management. NBS.	The teacher will introduce the topic to students, mainly what are NBS, what is its definition and what are the challenges of NBS, based on a reading in Annex 1. In Annex 2, the teacher can find two images that can be used in the slides to students to help show NBS. (Note: As an extra activity, students could create a book with what they learn throughout the LS with the online tool StoryJumper)	20 min
1b. Learn more about water management	In the same lesson, the teacher will explain: • What is water management in relation with NBS (see Annex 3. Should the teacher want to present using slides or visuals, an image can be found in Annex 4 as an example). • The next individual activity: The objective of this activity is for students to familiarise themselves with Natural Infrastructures for Water Management. The Teacher may use for the questionnaire "Do you Know what NIWM is?" provided in Annex 5 to review the content. To solve the questionnaire, students should consider the location of the image of the action related to water management is taking place. At the end of the questionnaire, the teacher can ask their students if they know more actions or if they think water management is so important in our lives. The last question of the questionnaire is to review all the actions water management is related in urban areas. Note for the teacher: In Annex 6 and Annex 7, teachers can find the solutions to the questionnaire of Annex 5.	20 min

Name of activity	Procedure	Time
1c. Water management video	The teacher presents a five-minute video to identify the Natural Infrastructures for Water Management., Access to recommended video: https://youtu.be/paVTJtgGFFU Urban Coastal Waterways: Can Blue be Green? https://youtu.be/64ppEihxFlA These videos help solve some of the questions of the questionnaire from the previous activity.	10 min
1d. Water management in urban areas	Addressing, discussing and answering the last question of the questionnaire, we review all the actions on water management related to urban areas. At this point we know the problems to be solved related to water management. In the next step, we engage the students in the first challenge.	10 min
Activity 2	In Annex 8 teachers can see an overview of the objectives that students can reach from following Activity 2: Choosing the best plants.	
2. Choosing the best plants (as Scientist)	In this lesson, the students will watch the video "Water management in urban areas" and video: https://www.youtube.com/watch?v=EXNt-bnfYME Students will help "Ramboll" by doing two different activities. The first will be to measure the transpiration rates of different plants with the support of the teacher. If the lessons are carried out remotely, and the students do not have all the necessary materials, we need to allow time for them to access some of them and find out what they need. Supporting material "Choosing the best plants": • Annex 9 provides pages for students to know the weather conditions in our garden • Annex 10 helps to introduce the theoretical explanation for the research. • Annex 11 shows the materials needed for the research. We use home materials, but in some cases, we can discover we do not have a scale, for example. We would then need to build a scale with home materials. Following this video, we can easily build a scale https://youtu.be/7Prz7n8cD9Q. • Annex 12 serves to remind the students the steps a scientist needs to complete the research. Annex 13 can be used as the template for students for their report, with questions and hypothesis to support the student in the new methodology. Sharing the results following the poster steps can help the students to present their research. • The teacher assessment can be done following the rubric in Annex 14.	60 min
Activity 3		
3. Choosing the best soil to work with	In this second activity we are going to help "Ramboll" to choose the best soil to work with. To find the best combination of soil for our garden, we will work as scientists and as engineers. As scientists, we will answer several questions and as engineers, we will solve our problem.	min

Name of activity	Procedure	Time
3a. Work as a Scientist	As a scientist of "Ramboll" we will look at the best combination of soil for our garden by applying the scientific method. See the supporting material in Annex 15 "Choosing the best soil combination to work with", where we provide: • The list of materials to work as scientists and engineers. • Methodology as a scientist has two different trials related to the questions. In the first we try to solve the first question "Which is the material with less storage capacity?" and the second trial is to solve the second question. • Before starting with the trials, the teacher should ask students the answer for the questions and write them bellow Hypothesis. • Results are separated in two tables to solve the two different questions. • Conclusions are related to the questions and the hypothesis which students offer as an explanation. • Finally, the students will share their research with others. Using a poster to present the results can help the students with the scientific method. Teachers can find the rubric to assess this task in (Annex 16)	60 min
3b. Work as engineer	As an engineer, we solve a problem by following the design method: • Annex 17: An engineer follows the design method to reach a solution for a problem. We can do four experiments or more to solve the problem. These experiments can be distributed among groups of students to avoid the task being too tedious. At the end of the experiments, the students will share their data table (Annexes 18, 19, 20 and 21 are the worksheets for each of the four experiments). • To share their final conclusions, students will have to follow the steps proposed in the poster, which are similar to those provided in the picture "The design Method" (see Annex 22 as an example of technological poster). In addition, this format can be easily assessed using the Rubric in Annex 23.	60 min

9. **Assessment**

- The document "Do you Know what NIWM is?" (Annex 5) was created to be able to obtain a numerical value, but it is also an evaluation to know the state of understanding of the students.
- The documents "Rubric 1, 2 and 3" (in Annexes 14, 16 and 23) include rubrics that will be used to carry out a summative evaluation of the scientific skills following the student's investigative and design method.

10. **Teacher's remarks**

In Annex 24 information has been added on how to adapt the learning scenario to remote teaching.

Annex 1: Nature-Based solutions

The concept of nature-based solutions (NBS) emerges from other ideas such a protecting ecosystems or tackling environmental and climate challenges. NBS are designed to bring more nature and natural features and processes to cities, landscapes and seascapes while supporting economic growth, job creation and human wellbeing.

The EU defines nature-based solutions to societal challenges as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services.

Figure 1: Image of Frank Winkler in Pixabay, https://pixabay.com/es/photos/casa-del-barco-casa-rural-aguas-192990/

NBS can help tackling several key challenges:

1. Climate mitigation and adaptation
2. Water management
3. Disaster risk reduction
4. Green spaces and urban regeneration
5. Public health, wellbeing and air quality
6. Participatory planning and governance
7. Social justice and social cohesion
8. Economic opportunities and green jobs

Annex 2: Nature-based solutions images for slides

Figure 2: Image of Peter H in Pixabay https://pixabay.com/es/photos/fuente-el-agua-el-flujo-de-mojado-3412242/

Figure 3: Image of James Wheeler in Pixabay, https://pixabay.com/es/photos/edificios-torre-cn-canada-colorido-2297210/

Annex 3: Water management

Water management is the control and movement of water resources to minimise damage to life and property and to maximise efficient beneficial use.

Cities and towns are facing real water challenges. A recognition of ongoing urban water management challenges, brought to front of mind during the millennium drought, and furthermore through local flooding and water pollution events. A good water management plan should include:

- Sustainable water-use plan, to provide access to clean drinking water and improve community health.
- Integrated water management strategy, restoring degraded terrestrial ecosystems and improving living conditions for wild species.
- Flood and drought studies, to reduce the risk of floods and droughts
- Stormwater management plan, like in the case study "Cloudburst Management Plan" Copenhagen <https://oppla.eu/casestudy/18017>

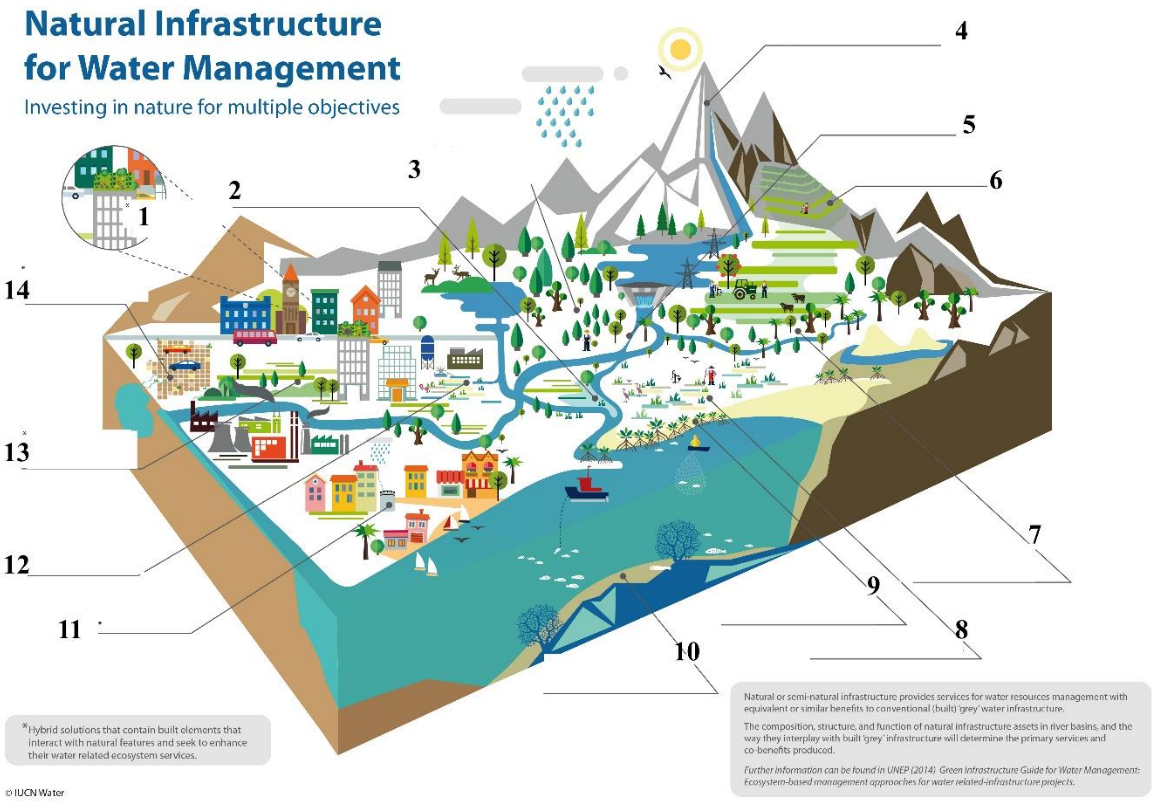
Figure 4: Image of Rony Michaud in Pixabay, https://pixabay.com/es/photos/gotas-de-agua-el-agua-liquido-578897/

Annex 4: Water Management in Urban Areas image for slides

Figure 5: Image of JPlenio in Pixabay, https://pixabay.com/es/photos/toronto-horizonte-aguas-3112508

Annex 5: Questionnaire on Natural Infrastructure for Water management

1. **Match the correct answer with the corresponding number**



	Number
A. Growing crops across slopes to reduce erosion & increase infiltration	
B. Providing riparian buffers to maintain water quality & reduce erosion	
C. Conserving and restoring wetlands	
D. Protecting and restoring mangroves, coastal wetlands & dunes	
E. Protecting and restoring reefs for coastal protection and habitat	
F. * Water harvesting	
G. Purifying wastewater & alleviating flooding (healthy wetlands)	
H. Establishing flood bypasses to reduce downstream flooding	
I. *Providing infiltration & bioretention (urban green spaces)	
J. *Improving infiltration using urban run-off (i.e. permeable pavements)	
K. *Capturing rainwater with green roofs	
L. Connecting rivers to floodplains & aquifers	
M. Forest landscape restoration to reduce flood impacts, stabilise slopes & provide clean water	
N. Conserving & protecting water sources	

2. **Do you know which of these Natural Infrastructures for Water Management are related to urban areas? (Clue: there are 7 correct answers)**

Figure 6: CC - Author Another_Simon https://pixabay.com/es/photos/toronto-horizonte-canada-4720225/

A. Growing crops across slopes to reduce erosion & increase infiltration
B. Providing riparian buffers to maintain water quality & reduce erosion
C. Conserving and restoring wetlands
D. Protecting and restoring mangroves, coastal wetlands & dunes
E. Protecting and restoring reefs for coastal protection and habitat
F. * Water harvesting
G. Purifying wastewater & alleviating flooding (healthy wetlands)
H. Establishing flood bypasses to reduce downstream flooding
I. *Providing infiltration & bioretention (urban green spaces)
J. *Improving infiltration using urban run-off (i.e. permeable pavements)
K. *Capturing rainwater with green roofs
L. Connecting rivers to floodplains & aquifers
M. Forest landscape restoration to reduce flood impacts, stabilise slopes & provide clean water
N. Conserving & protecting water sources

Annex 6: Solution to question 1 of the activity on Natural Infrastructure for Water Management

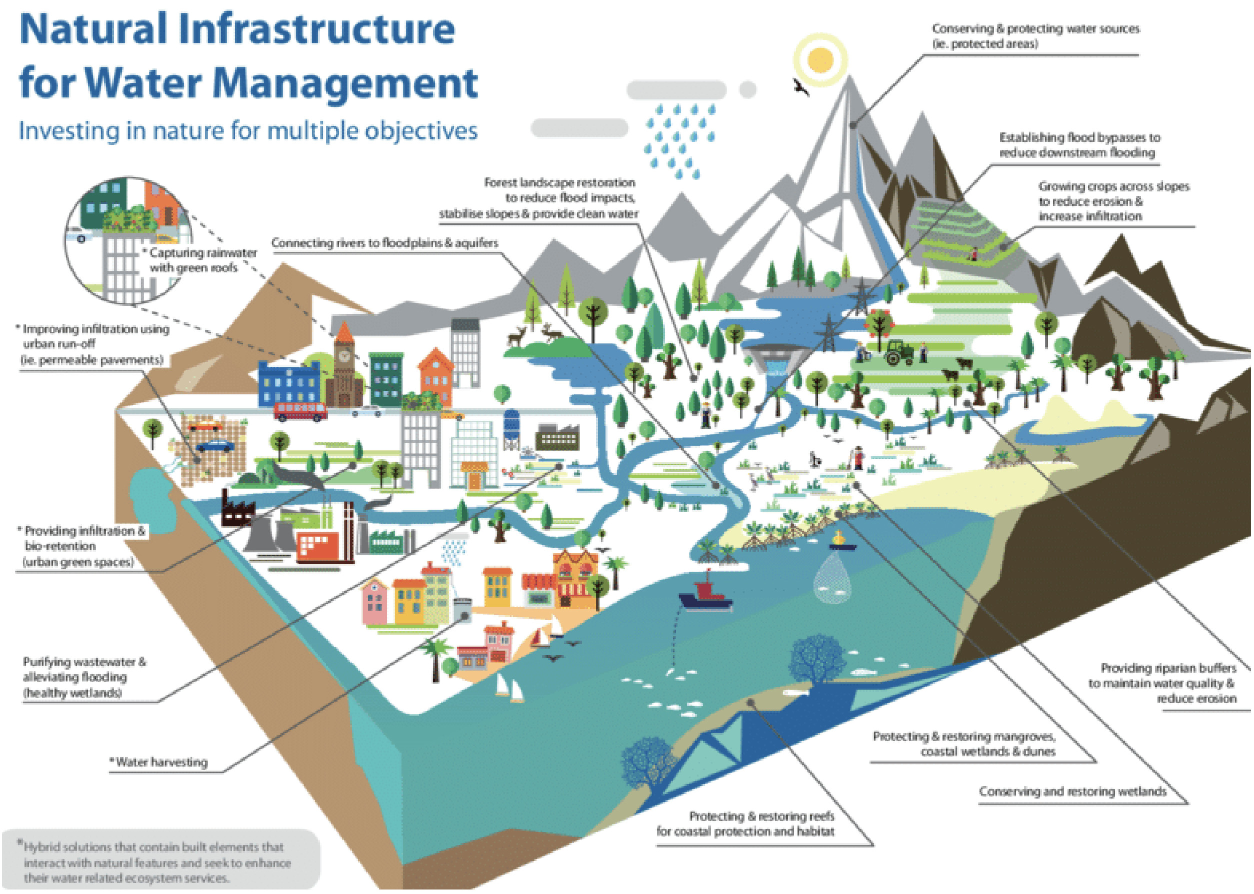


Figure 7: Infographic 'Natural Infrastructure for Water Management', © IUCN Water 2015, https://twitter.com/UNaLab_EU/status/978538286070329344/photo/1

Annex 7: Answers to question 2 in the Annex 5 questionnaire

To cut

1. *Water harvesting

2. Purifying wastewater & alleviating flooding (healthy wetlands)

3. Establishing flood bypasses to reduce downstream flooding

4. *Providing infiltration & bioretention (urban green spaces)

5. *Improving infiltration using urban run-off (i.e. permeable pavements)

6. Capturing rainwater with green roofs

7. Connecting rivers to floodplains & aquifers

Annex 8: Understanding the hydrologic cycle: A water balance analysis[1]

To understand the concepts explained in Activity 1, it would be good to conduct multi-trial experiments, so students are able to see and measure something that is invisible to them: precipitation, water retention, ground water storage and evapotranspiration.

After these experiments, students should be able to:

- Differentiate the work of an engineer and a scientist.
- Explain how to apply these concepts to the urban water cycle.
- Calculate the evapotranspiration in plants
- Create a graph of collected data and select plant species based on the evapotranspiration data.

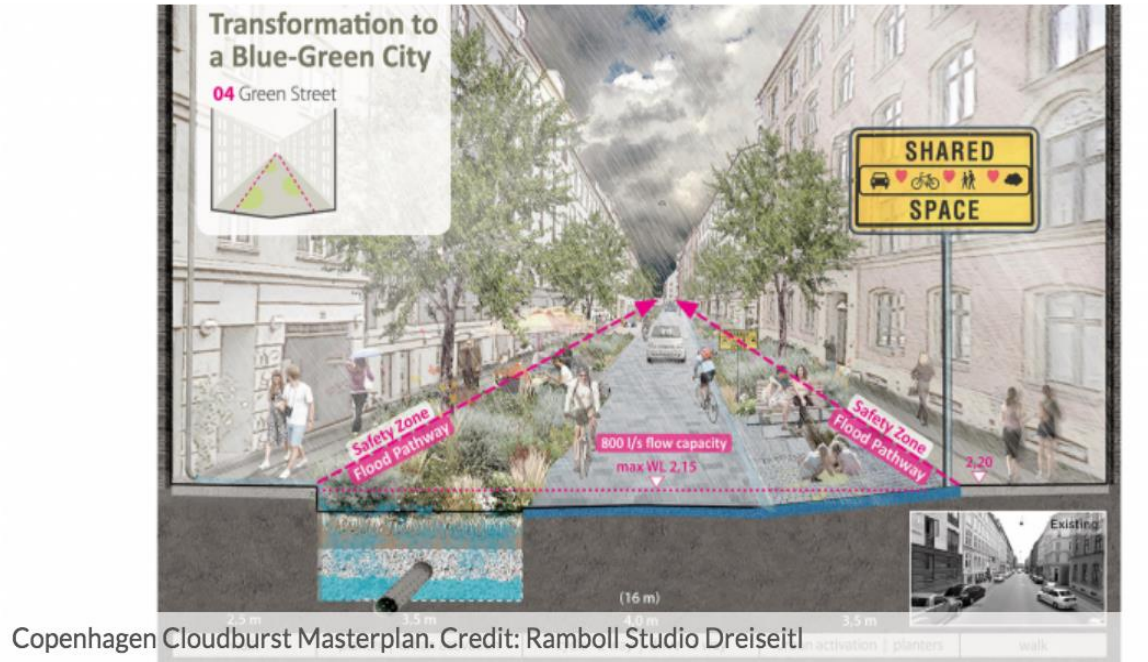


Figure 8: Slideshow taken from Case of study "Cloudburst Management Plan, Copenhagen" Oppla https://oppla.eu/casestudy/18017

[1] The following article explain the importance of plant type in water management systems: https://link.springer.com/article/10.1007/s11252-018-0822-2

Annex 9: Pages for students

Measuring water distribution in a garden[2]

Name…………………………………………………. Date…………………….

Measuring as a scientist

Temperature……………..Humidity……………………

Weather conditions………………………………………………………………………………………

[2] The following experience “Measuring water distribution in a garden” is adapted from “Just Breathe Green: Measuring Transpiration Rates” Available at: <https://www.teachengineering.org/activities/view/usf_stormwater_lesson02_activity1>

Annex 10: Theoretical explanation[3]

Rain falling at soil surface may

a. infiltrate and be stored in the root zone, or
b. pass downwards to groundwater, or
c. be stored in surface depressions to either infiltrate or evaporate or run off over the surface.

These disposal routes are represented in a field water balance equation (Verplancke *et al*. 1988) adapted as**: P = M + U + *S*Edt**

Where the letters in the formula stand for:

P is rainfall or precipitation received, that we can measure with water weight.

M is increase in soil water storage.

U is increase in the groundwater storage, and

***S*Edt** is the total evaporation over a period.

Runoff is perhaps the greatest water management problem on rainfed croplands because not only it loses of a potential water resource, but it may cause damaging soil erosion.

[3] According to FAO Soils Bulletin 69-1993 – Available at: http://www.fao.org/3/t1696e/t1696e02.htm

Annex 11: Materials list

Each group needs:

- 2 plants, in 10 cm containers
- (1) 2-liter plastic bottles
- Scale, accurate to 1 gram. If the students don´t have a scale at home they can make their own following this video <https://youtu.be/7Prz7n8cD9Q>
- 2 stopwatches or timers
- Calculators
- Dish (Not necessary blue)
- Pencils, coloured pencils or markers
- Graphic ruler

Figure 9: a) Image of plant and dish; b) Image of the student Inés Martínez with the home-made scale made following the video <https://youtu.be/7Prz7n8cD9Q> Photo published with the consent of the minor's parents

Annex 12: Activity Method

1. Weigh the plant. Write down the initial plant weight.
2. Water your plant until soil is complete saturated. This is the P value.
3. After 40 minutes weight the blue dish and get the U value, ground water storage.
4. Weight the plant and calculate the difference from the initial weight. The result will be the M value, the water retention.
5. To calculate the evapotranspiration, apply the formula **SEdt= P-M-U**

Annex 13: Working as a scientist

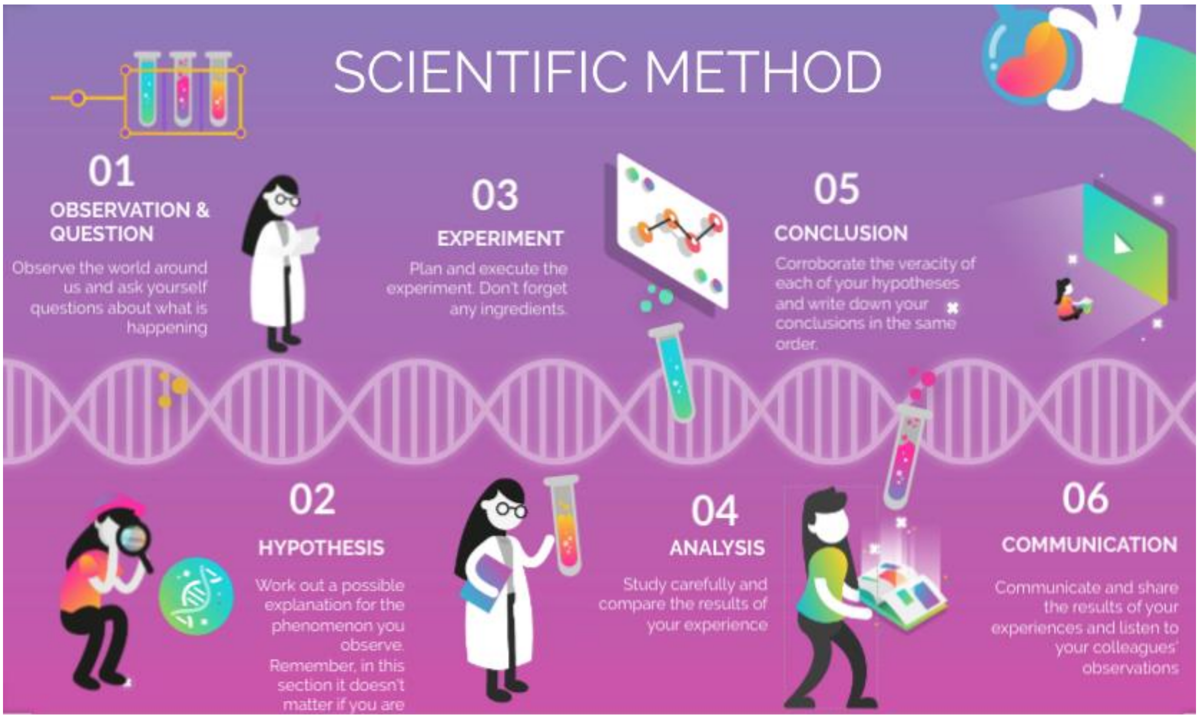


Figure 10: Diagram Made by Jose Viñas with Genially. HTTPS://APP.GENIAL.LY/DASHBOARD CC-BY

Questions

1. What are the characteristics that make your plant a good candidate for a green roof?

2. If you have another question, please write it here:

Hypothesis

Choose one of the following:

☐ The plant which the best water retention

☐ The plant which the best groundwater storage

☐ The plant which the best evaporation

If you have another hypothesis, please write it here:

Evidence- Results of the experiment

Complete this table:

Common name *Scientific name*

Method		Observations
Initial plant weight		
P- Water weight		
M- Water retention		
U- Ground water storage (Weight blue dish)		
SEdt= P-M-U		

Outstanding incidents during the experience

Conclusion

Consider which of the hypotheses is the most appropriate after having carried out the experience and share it with your colleagues in the place indicated by the teacher

Share your research

Follow this poster model to present your research in class.

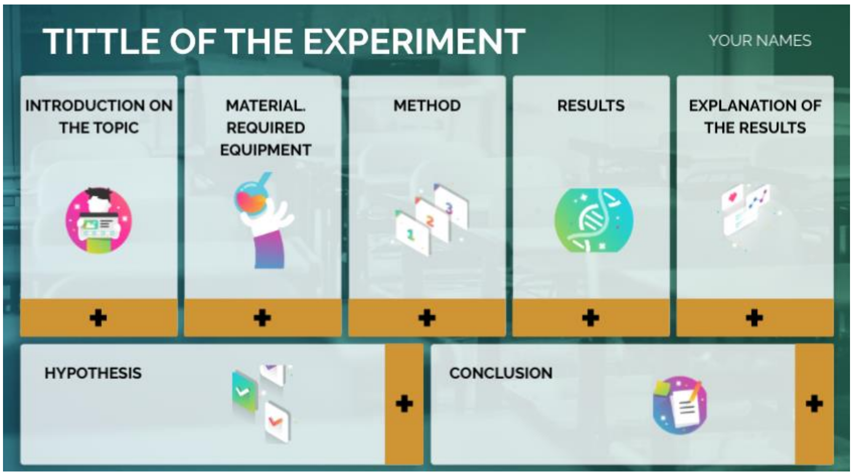


Figure 10: Diagram made by Jose Viñas with Genially. <HTTPS://APP.GENIAL.LY/DASHBOARD>

As a scientist, you can compare your results with those of other students and, by attending water retention, groundwater storage and evaporation, you can indicate which plant is best for our street-garden.

Annex 14: Rubric 1 for Scientific research – NBS Water distribution in a garden

Scientific research- NBS Water distribution in a garden	**Bellow standard**	**Close to standard**	**Standard performance**	**Above the standard**
Raising issues	It only asks one question to answer the phenomenon	Ask several questions to answer a phenomenon	Several questions are asked differentiating the useful from the not useful	Modify the questions so that they can all be evaluated with the research.
Hypothesis	The editorial staff does not make any assumptions	Marks 1 or more of the presented hypothesis	It elaborates more than one hypothesis in response to the question	When developing the hypotheses, it exposes some effect related to the variable
Experiment - act	Does not take measurements in an orderly manner	Takes measurements correctly, but without the necessary order of a table with units	Complete the data table with the correct units	Takes notes and makes a qualitative description of the process
Research - Calculation	It does not identify the measures to be calculated	It performs the measurement operations but does not relate them to the formula	Replaces the data correctly in the formula	Use the data in the formula correctly and attend to the units
Analyse	Does no attend to answer initial questions to interpret evidence	Attend to the initial questions to interpret the evidence	Make decisions based on the results obtained	It considers possible sources of error and indicates them
	It does not relate the conclusions to the hypotheses	Relates the conclusions to the hypotheses	Attends to the dependent and independent variables in the conclusion	Identifies patterns from the results
Report -tables	Does not perform the table according to the teacher's guidelines	The data are accurately recorded, considering the units, without differentiating between dependent and independent variables.	The rows and columns put the dependent and independent variables in the right place.	Correct title and format of the table.

Annex 15: Worksheet: Choosing the Best Soil Combination to Work With

Knowing that the work – in this case the lesson – was implemented online, the teacher will take into account the availability of material from each of his students. In this project, we use gravel, humus, sand, and hardwood mulch, so it would be appropriate to make groups of students who could provide all four materials. Following, the data gathered will be shared in a way that the teacher considers appropriate.

The best mix for our street-garden[4]

In the first phase of this activity, we will act as scientists, in the second one we will be engineers.

- **As a scientist,** we will answer questions.
- **As an engineer,** we will solve a problem.

Materials List

Each group needs:

- 30 cm of fabric
- Vegetable sieves
- 5-liter bucket, to catch draining water
- Chronometer
- Measuring cup, volumetric cylinder or some other graduated plastic container, for measuring water volume
- "*The best mix for our street-garden*" Worksheet, one per student

From the following materials, each student will choose the one they have at home. The students who are fortunate to have all four materials will be our engineers.

- 2kg construction/playground sand
- 2kg. bag soil compost
- 2kg. bag 10/15 cm limestone or pea gravel
- 0,5 kg bag hardwood mulch.

[4] Experience "*The best mix for our street-garden" is adapted from "Does Media Matter? Infiltration Rates and Storage Capacities"* <https://www.teachengineering.org/activities/view/usf_stormwater_lesson02_activity2>

First Trial

1. Take 1 vegetable sieve and cover it with fabric
2. Put on 5-litre bucket to catch draining water
3. Add 2kg of sand, compost, gravel, or mulch on the fabric
4. Add 3 litres of water.
5. Wait for 4 minutes and measure **Drained volume** in a volumetric cylinder.
6. Calculate Storage capacity: **Storage Capacity = Water Volume - Drained Volume**
7. Fill the data in **Table 1**.

Second trial

1. Take 1 vegetable sieve and cover it with fabric
2. Put on 5-litre bucket to catch draining water.
3. Add 2kg of sand, compost, gravel, or mulch on the fabric
4. Add 3 litters of water each
5. Measure the time to drain 1500 ml of water.

Calculate infiltration time dividing 1500 ml by the time in seconds. We will thus calculate the ml infiltrated per second IR= 1500ml/Time(s)

As scientists we can answer the next questions:

Which is the material with less storage capacity?

Which is the material with less infiltration rate? Remember, the infiltration rate will tell us the absorption capacity of the soil in case of heavy rain. It will, therefore, prevent water from flowing on the surface and causing flooding.

Try to do an explanation with **Hypothesis**

Results

Table 1: Results for storage capacity

Material	Water Volume	Storage capacity	Drained volume (ml)	Observations
Sand	3 litres			
Soil-Compost	3 litres			
Gravel	3 litres			
Mulch	3 litres			

Table 2: Results for infiltration rate

Material	Water volume	Time to drain (s)	Drained volume (ml)	Infiltration rate (ml/s)	Observations
Sand	3 litres		1500		
Soil-Compost	3 litres		1500		
Gravel	3 litres		1500		
Mulch	3 litres		1500		

After our results and according to our observations, as a scientist, we can draw our conclusions

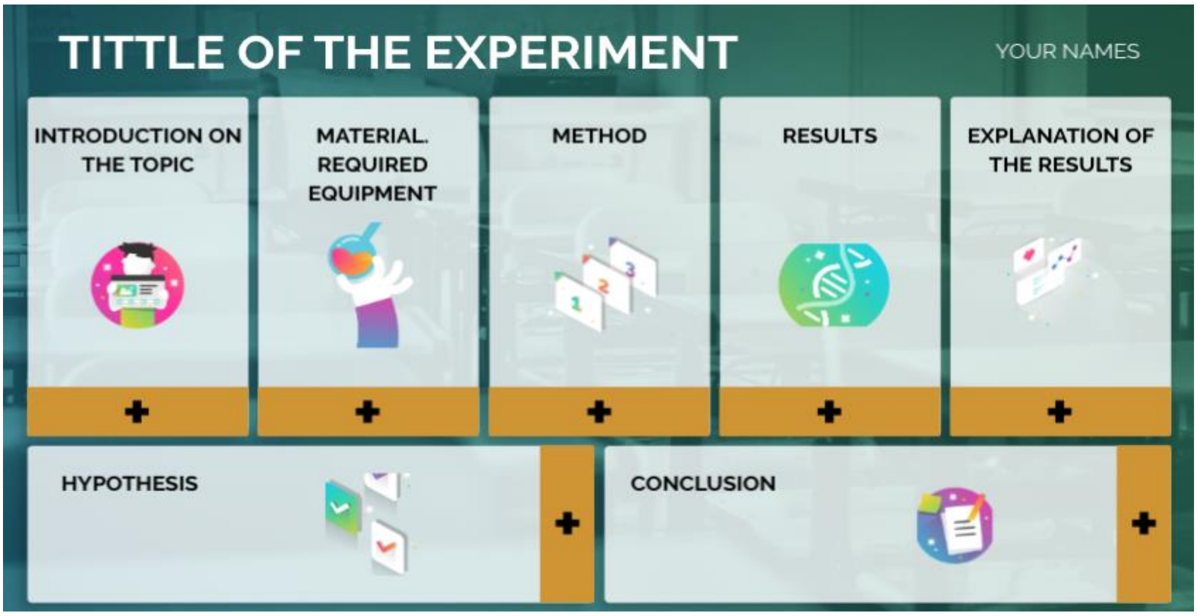
Conclusions

The material with less storage capacity is… (Clue: you should look at the results obtained in table 1)

The material with less infiltration rate is… (Clue: you should look at the results obtained in table 2)

Share your research

Follow the following poster model to present your research in class.



Annex 16: Rubric 2 Scientific research – NBS Choosing the best soil

Scientific research- NBS Choosing the best soil	Bellow standard	Close to standard	Standard performance	Above the standard
Hypothesis	The editorial staff does not make any assumptions	Marks 1 or more of the presented hypothesis	It elaborates more than one hypothesis in response to the question	When developing the hypotheses, it exposes some effect related to the variable
Experiment – act	Does not take measurements in an orderly manner	Takes measurements correctly, but without the necessary order of a table with units	Complete the data table with the correct units	Takes notes and makes a qualitative description of the process
Research – Calculation	It does not identify the measures to be calculated	It performs the measurement operations but does not relate them to the formula	Replaces the data correctly in the formula	Use the data in the formula correctly and attend to the units
Analyse	Does no attend to answer initial questions to interpret evidence	Attend to the initial questions to interpret the evidence	Make decisions based on the results obtained	It considers possible sources of error and indicates them
Conclusions	It does not relate the conclusions to the hypotheses	Relates the conclusions to the hypotheses	Attends to the dependent and independent variables in the conclusion	Identifies patterns from the results
Report – Table	Does not perform the table according to the teacher's guidelines	The data are accurately recorded, considering the units, without differentiating between dependent and independent variables.	The rows and columns put the dependent and independent variables in the right place.	Correct title and format of the table.

Annex 17: As an engineer

When scientists want to answer a question, they follow the scientific method we have seen before. When engineers have a problem, they follow the design method shown in Figure 12

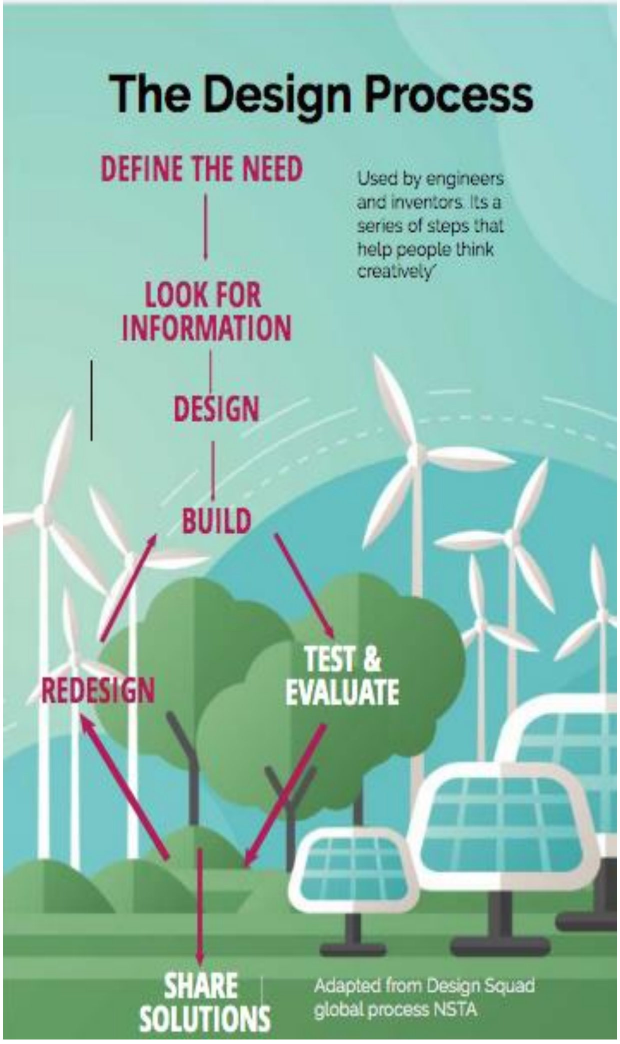


Figure 12: Diagram 3. Made by Jose Viñas With Crello.Https://Crello.Com/ CC-BY

Define the need. Identify the problem to be solved.

Look for Information. Brainstorm and search for information.

Design. Drawing and putting our idea on paper.

Build. Build a prototype.

Test & Evaluate. Test the functionality of our prototype. If everything has gone well, which is not usually the case, we will then share our solution.

Redesign. Every invention and design process can be improved, meaning that if our testers or ourselves are not convinced of the result, it is advisable to redesign and build a new one to perfect it.

Some ideas: We need to solve a problem: which is the best mix combination of materials based on previous test results and observations.

Design requirements: it is important to create a layer that promotes infiltration, maximises groundwater storage and provides an environment for healthy plants and microbial communities.

Experiment	Material 1	Material 2	Material 3	Material 4
	Sand	Gravel	Soil	Mulch
1	1 part	1 part	1 part	1 part
2	2 parts	0 parts	2 parts	1 part
3	1 part	1 part	2 parts	0 part
4	2 parts	1 part	3 parts	0 part

Annex 18: Results experiment 1

Experiment 1	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume[5]
Trial 1	1000			
Trial 2	1000			
Trial 3	1000			
		Average		
Experiment 1	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	2000			
Trial 2	2000			
Trial 3	2000			
		Average		
Experiment 1	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	3000			
Trial 2	3000			
Trial 3	3000			
		Average		

[5] Always half of the Volume of water for example for 1000ml volume water 500 ml of drained volume.

Annex 19: Results experiment 2

Experiment 2	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume[6]
Trial 1	1000			
Trial 2	1000			
Trial 3	1000			
		Average		
Experiment 2	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	2000			
Trial 2	2000			
Trial 3	2000			
		Average		
Experiment 2	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	3000			
Trial 2	3000			
Trial 3	3000			
		Average		

[6] Always half of the volume of water for example for 1000ml volume water 500 ml of drained volume.

Annex 20: Results experiment 3

Experiment 3	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume[7]
Trial 1	1000			
Trial 2	1000			
Trial 3	1000			
		Average		
Experiment 3	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	2000			
Trial 2	2000			
Trial 3	2000			
		Average		
Experiment 3	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	3000			
Trial 2	3000			
Trial 3	3000			
		Average		

[7] Always half of the volume of water for example for 1000ml volume water 500 ml of drained volume.

Annex 21: Results experiment 4

Experiment 4	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume[8]
Trial 1	1000			
Trial 2	1000			
Trial 3	1000			
		Average		
Experiment 4	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	2000			
Trial 2	2000			
Trial 3	2000			
		Average		
Experiment 4	Volume of water (ml)	Time (s)	Infiltration rate	Drained volume
Trial 1	3000			
Trial 2	3000			
Trial 3	3000			
		Average		

[8] Always half of the volume of water for example for 1000ml volume water 500 ml of drained volume.

Annex 22: Share the solution with your colleagues.

Follow this poster model to present your project in class. According to the data shared by your fellow engineers, all students can draw their own conclusions and indicate which was our prototype based on the scientists' results, our current prototype based on the engineers' results and the improvements we consider should be made.

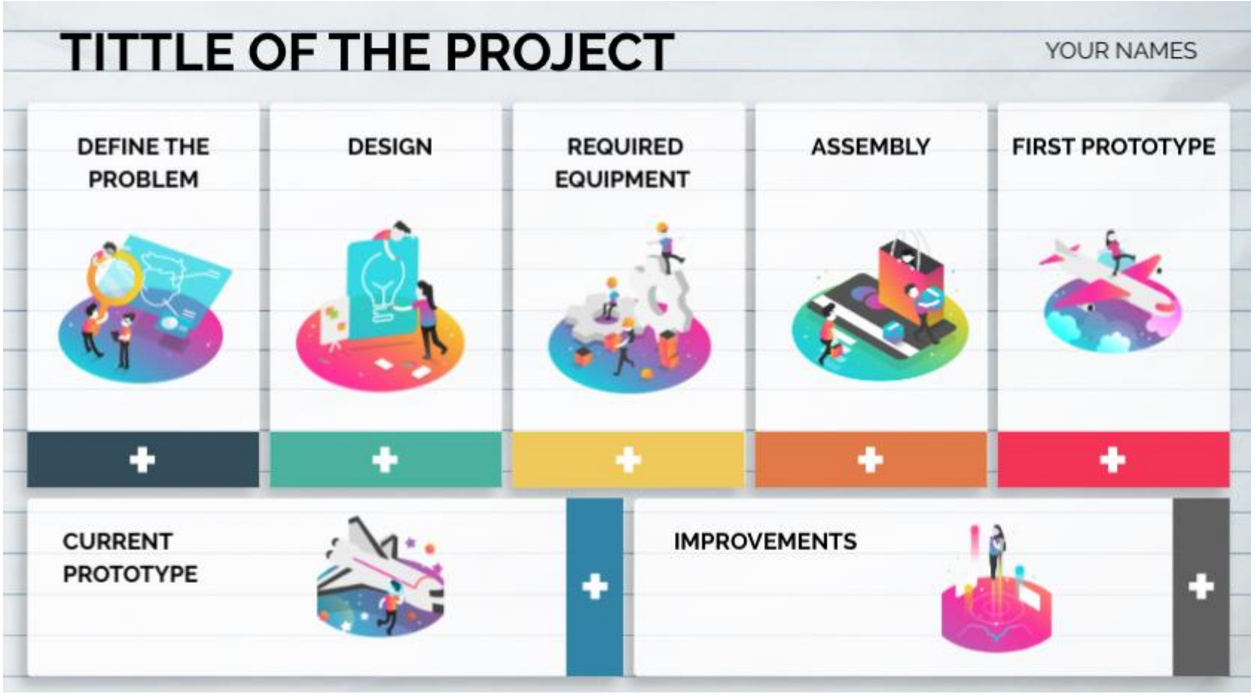


Figure 13: Diagram made by Jose Viñas with Genially. <HTTPS://APP.GENIAL.LY/DASHBOARD>. CC-BY

Annex 23: Rubric 3. Design Process – NBS Choosing the best soil

Design Process – NBS Choosing the best soil	Bellow standard	Close to standard	Standard performance	Above the standard
Define the problem	Fails to define the problem	Defines only part of the problem	Define the entire problem	Defines the entire problem and links it to the solution of other problems
Required equipment – Assembly	Does not use the proposed equipment and requirements	Use the right material but not in the right proportions	Use the right material and proportions	Uses the right proportions and solves problems that arise during the process
First Prototype-Current prototype	It shows no solution.	Solution not analysed in depth	It shows a correct solution, according to the results	Correct solution and also evaluates the possible improvements of the mixtures
Calculation	It does not identify the measures to be calculated	It performs the measurement operations, but does not relate them to the formula	Replaces the data correctly in the formula	Use the data in the formula correctly and attend to the units
Report - Table	Does not perform the table according to the teacher's guidelines	The data are accurately recorded, taking into account the units, without differentiating between dependent and independent variables	The rows and columns put the dependent and independent variables in the right place	Correct title and format of the table.

Annex 24: Adaptation to online implementation

1a) The teacher will introduce the topic to the students, based on the reading of the documents/materials present in this LS. Online class.

1b) Group game, in which students will familiarise themselves with Natural Infrastructures for Water Management in a fun way: I had to change this activity into an online survey.

1c) Display the five-minute video to identify the Natural Infrastructures for Water Management.

1d) The physical poster created in class, was converted to digital posters or images shared via virtual classrooms.

2) Choosing the best soil to work with. To find the best combination of soil for our garden, we will work as scientists and as engineers. As scientists, we will answer several questions and as engineers, we will solve our problem. This practice was also adapted according to the materials the students have at home. The aim is to divide the work by groups and share the results in a drive document.

3) Choosing the best plants. Measuring transpiration rates. This activity was also adapted to experimenting at home. It was necessary to change and simplify the experiment because not all students have all the necessary tools for example scale. So, the idea is to build a scale with things students have at home – sparkling their creativity.

Note: when the work is designed for the class, the teacher can be in charge of buying material to make it homogeneous, in this case, we must solve problems such as the different size of the plants of each student or different kind of soil. We likewise have to take the measuring tools into account, as some students might have to build their own scales due to not having them at home, or obtaining materials such as humus, sand and gravel. These can cause delays in receiving results, and increase the time needed for the activities. Progress, in this situation, is slower.

Additional suggestion: the best way to run hands-on activities online with the students is instead of explaining in a text or a protocol, do these hands-on activities at the same time (live), teacher and students, teacher at school or at home and students at home with their own materials. If they do not have materials themselves, school should send a kit by post.

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About the NBS project

The NBS project is initiated and funded by the European Commission Directorate-General for Research and Innovation and coordinated by PPMI, in collaboration with European Schoolnet (EUN). PPMI (www.ppmi.lt/en) is a leading European research and policy analysis centre, aiming to help public sector and civil society leaders from around the world, presenting evidence in a way that is simple, clear and ready to use. European Schoolnet (www.eun.org) is the network of 34 European Ministries of Education, based in Brussels. EUN aims to bring innovation in teaching and learning to its key stakeholders: Ministries of Education, schools, teachers, researchers, and industry partners. Find out more about nature-based solutions: https://ec.europa.eu/research/environment/index.cfm?pg=nbs and all the NBS Learning Scenarios created in this project as well as the overall reports can be found at http://www.scientix.eu/pilots/nbs-project

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This learning scenario encourages students to learn and care about the importance of water management to tackle urban challenges such as floods and disruption of the water cycle in the urban environment via nature-based solutions (NBS). Through the activities, students will work as scientists following the approach of Inquiry-based learning by following the design process as engineers (or landscape architects). The main topic discussed will be based on the case study “Cloudburst Management Plan, Copenhagen” from <https://oppla.eu/casestudy/18017>.

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