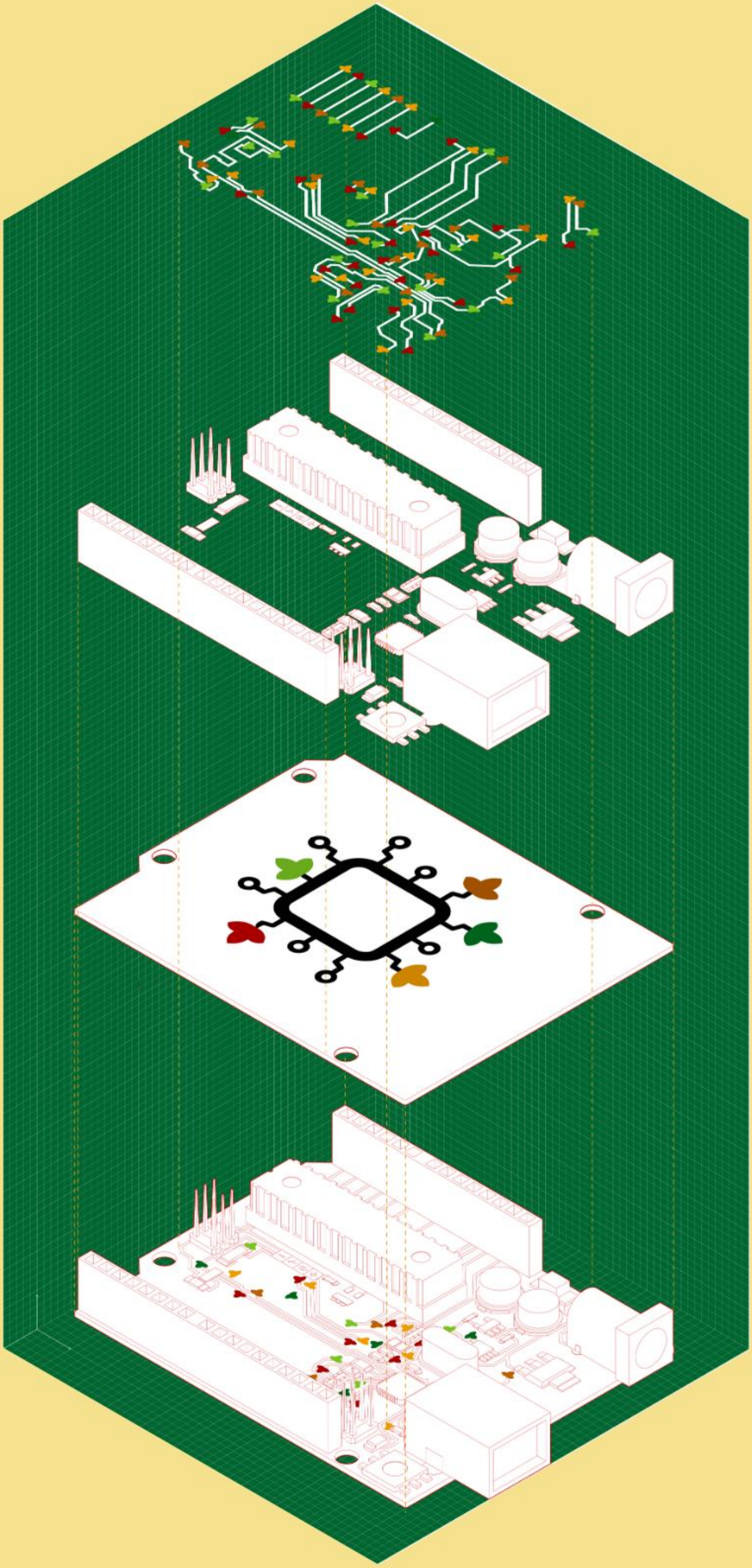
Green
STEAM
Incubator

The "Green STEAM Incubator" MANUAL



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CHAPTER 1

1.1 The state of the EU agricultural sector

"Young people should be at the forefront of global change and innovation. Empowered, they can be key agents for development and peace. If, however, they are left on society's margins, all of us will be impoverished. Let us ensure that all young people have every opportunity to participate fully in the lives of their societies."

Kofi Annan, Ghana, the seventh Secretary-General of the United Nations (Commonwealth Secretariat, n.d.)

In the course of the past hundred years, agriculture has been turned from the main source of income across the majority of households in Europe to employing around 8.9% of EU's working force in 2016 (Eurostat, 2018a) and amounting to 1.1% of the Union's GDP in 2018 (Eurostat, 2019a). Widespread urbanization, our contemporary, quick paced and technologically-pervasive way of life, altering environmental conditions and the increasingly demanding standards for food production have all posed challenges to the growth of the sector. Another detrimental factor is the flow of new blood into the sector, or rather, the lack of it. According to the latest data from Eurostat, the statistical office of the European Union (2018a), in 2016, nearly 6 out of 10 farmer managers in the EU-28 were 55 years old or more, in contrast to less than 1 in 10 young people under the age of 34 working for the same position (see figure 1).

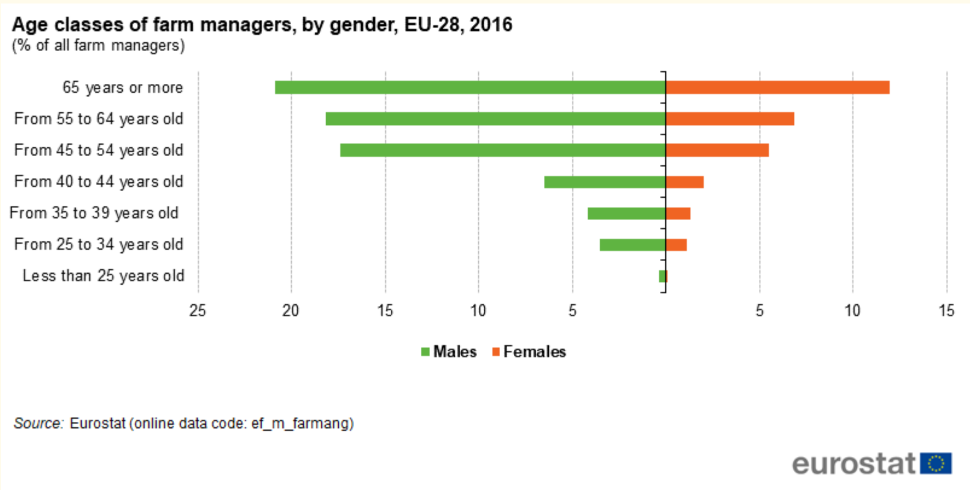

Figure 1 - Age classes of farm managers, by gender, EU-28, 2016 (Eurostat, 2018b

When taking a closer look to the member states with the lowest proportions, such as Cyprus and Portugal, the figures are particularly disheartening for the future of the field, as in Cyprus only 1.31% of farmer managers are under 34 years old, while in Portugal only 1,89% (Eurostat, 2018c). At the same time, agriculture is a profession that tends to either be passed down from generation to generation (Eurostat, 2018b) or is exercised by practical experience (Unit Farm Economics: DG Agriculture and Rural Development, 2017, p.7). The latter is especially reflected in the number of young farm managers who completed a full agricultural training cycle in 2013 (19.8%), in comparison to the ones who operate through hands-on experience (61.6%) (Unit Farm Economics: DG Agriculture and Rural Development, 2017, p.7). A conclusion that could be drawn from the above metrics is that the European agricultural sector is in pressing need for a boost in the involvement of young and educationally accredited people.

Attaining an educational training is of particular significance when taking into account the consumers' demanding standards for food production (ex. organic products) and the urgency to prevent further biodiversity loss, land degradation and the overall impact of climate change. In the 2019 report on "Climate change adaptation in the agriculture sector in Europe" (Jacobs *et al.,* 2019), the European Environment Agency warns of a loss up to 16% in the EU agricultural income by the next 30 years, unless drastic measures are taken to render agricultural production sustainable. Meanwhile, agro-ecological approaches, like organic farming and permaculture, draw on the interactions between plants, animals, soil organisms, people and the environment; specifically, on practices such as the rotation of crops, no human intervention, limited or no waste production and reduced energy inputs among others. As a result, we can observe an optimization in the use of natural resources, an intensification of biological processes in the soil and an amelioration in the biomass, nutrient, carbon and water cycles (EIP-AGRI, 2020). When agro-ecology is combined with scientific methodologies and technological innovations, this can help "develop more sustainable and resilient farming systems that combine stable yields with enhanced biodiversity and ecosystem service" (EIP-AGRI, 2020, p.3). Additionally, the blending of the two fields can increase agricultural efficiency through automated monitoring, as well as prevent the use of pesticides and chemicals and reduce costs, which in turn can improve the price of food, the quality of products and the impact on the natural ecosystem.

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1.2 The project "Green STEAM Incubator"

In light of the low participation of youth in agribusinesses and the ongoing need for innovation in the field of agriculture and farming, our consortium with partners from Cyprus, Portugal and Belgium have created the Erasmus+ funded project "Green STEAM Incubator", in the context of which the current Manual is written. The goal of "Green STEAM Incubator" is to reignite the connection between young people and the farming sector by leveling contemporary realities with current practices, through the circulation of STEM methodologies (Science, Technology, Engineering, Mathematics).

In particular, "Green STEAM Incubator" aspires to engage youth (18-35 years old), so as to investigate the common boarders of STEAM and entrepreneurship, by identifying ways in which STEM-oriented knowledge can be utilized along the path of enhancing agriculture, environmental engineering and social innovation. Simultaneously, the project aims to set a fertile ground for the promotion of a culture of social enterprises, agrobusinesses and start-ups, capable of utilizing recent technological innovations. This will be accomplished through the creation of collaborative activities between agribusinesses and youth organizations, gamified methodologies in environmental STEM-oriented activities that relate permaculture, organic farming and environmental education, as well as by designing and delivering Modules for "Microcontrollers" and "3D Modelling" Youth Laboratories (Incubators), where young people will acquire knowledge on how to design and promote holistic, high-tech solutions for sustainable communities, that originate from the STEM sector.

1.3 Aims and structure of the IO1: "Green STEAM Incubator" Manual

To this end, the first step would be to create a framework that will bring young people closer to farms and encourage them to develop an understanding about the way they operate. This will be done in the form of collaborative, on the spot activities between youth organizations/ youth workers and agricultural stakeholders, which will introduce youth to the agribusiness life, to concepts such as environmental education, permaculture, and to the technological equipment used.

However, before designing such activities, which will be included in chapter 4 of the Manual, the project partners have conducted interviews with agro-entrepreneurs in

Cyprus, Belgium and Portugal. The objectives were to discuss with practitioners of the agricultural field and receive information about their current operations, collaborations and needs, especially in terms of technological and STEM-related equipment. In the following chapter, we will present a collation of the interview outcomes and identify the core needs of farmers across the 3 countries of the project.

In Chapter 3 of the Manual, we will examine in detail why it is important for youth organizations and young people to develop collaborations with the agricultural sector. Last but not least, we will also analyse in depth the main terms that fall under STEM, as well as the concept of Design Thinking Model and how these can be applied to the notion of agriculture.

In the final and fifth part of the Manual we will provide an online library of useful material and extra resources and feedback of participants, which arose from the on the spot implementation of the youth activities at the agribusinesses.

CHAPTER 2

A GLIMPSE INTO AGRICULTURAL ENTERPRISES (BELGIUM, CYPRUS, AND PORTUGAL)

2.1 Presentation of the case studies

From our experience, the most informed way to grasp and identify the ongoing needs of a group of people is by coming into direct contact with them, preferably at their field of operation. Hence, in order to establish the needs of agro-entrepreneurs in terms of green technological equipment in Belgium, Cyprus and Portugal, the project partners conducted interviews with one or more farms working with agro-ecological methods. Depending on the restrictions of movement due to COVID-19 in each country at the time, some of the interviews took place through online questionnaires, others through virtual meetings and one on the spot at a farm.

The Belgian partner, Logopsycom, interviewed the organic farm "La Ferme Bio du Petit Sart" ("Homepage", n.d. a), which was founded in 2014 along with the Foundation Generations.bio and is located in Grez-Doiceau (Province of Brabant Wallon). Apart from breeding Limousine cows, managing organic field crops and gardening rare or forgotten vegetables, the agri-business is also open to visitors. Accordingly, it offers a wide range of educational, cultural and awareness-raising activities, such as workshops for organic gardening, cooking classes, conferences and film screenings regarding sustainable development. (Op Der Beek, May 18 2020, online interview).

The applicant partner from Cyprus, CIP Citizens in Power, visited Riverland Dairy Bio Farm at Kampia, Nicosia for a discussion with the owner and president of the Cypriot Association of Organic Farmers ("Riverland Bio Farm", n.d). Whereas the enterprise initially started out as a farm with ovine and caprine animals, aiming at producing organic dairy products, vegetables and herbs, it was gradually transformed to a visitor-friendly place that is currently fully accessible to the public. Some of the available activities (hands-on, indoors, and outdoors) targeted for children, but also visitors of all ages, are educational seminars on healthy, organic and sustainable living and agriculture, farm-based activities like walking the animals for grazing, athletic activities in the surrounding valley, camping opportunities and annual farm festivals. The business operates based on permaculture principles, like repurposing all waste, water, utilizing renewable energy sources and emitting a 0 CO_2 footprint, so as to preserve the environment and exert limited impact on it. (Kyprianou, May 08 2020, personal interview).

Figure 2 - Riverland bio farm

Figure 3 - Riverland bio farm

Figure 4 - Riverland bio farm

The second partner from Cyprus, Center for Social Innovation (CSI) approached "Ygea farm", which is located at Mathiatis, Nicosia ("Home", n.d). The name derives from a combination of the ancient Greek word for land or earth (gaia/gaea) and the modern Greek word for health (ygeia) (Konstantinides May 12 2020, online interview). The bio-farming company was established following sustainable farming practices and is environmentally responsible. The owners of the farm aim to contribute towards nature conservation, production of high quality of products and inspiring young people to follow the way of life and work that they promote. Specifically, the farm deals with crops, as well as with the production of organic chicken, organic eggs, organic olive oil and organic honey. Even though, currently it is not open to the public, the plan for the future is to make it accessible to visitors.

The fourth member of the consortium, CEPROF from Portugal, undertook three interviews with local agricultural stakeholders, namely with Agriplanet, Terracrua Design and Cultibaga. All three focus on production and on the provision of services to other stakeholders in the agricultural field.

Starting from the first enterprise, Agriplanet is located in Mogadouro, Bragança, and focuses on the provision of sustainable agricultural solutions and training services to the area ("Home", n.d.). In particular, their services include the planting of vines and various fruit trees, the conduct of soil analyses, land preparations with technologically advanced equipment, as well as the consulting of other farmers in using more environmentally friendly and cost-efficient methodologies (Patrão, May 8 2020, online interview).

The second interviewed Portuguese business, Terracrua Design, is placed in Odemira, Beja and specializes on regenerative planning, holistic grazing systems, permaculture approaches and keyline design ("Home", n.d.). With their target audience being agricultural entrepreneurs in ecological and regenerative fields, Terracrua Design offers consultancy services, design and structural planning services for farms and estates based on maps and topographic surveys. Also, it coordinates the implementation, maintenance, monitoring and management of assigned projects (Mamede Santos, May 4 2020, online interview). All the above are conducted following permaculture methodologies, because as the founder of the company explains: "In essence, permaculture is a kind of idea or philosophy, somewhat conceptual, on three ethical principles: taking care of the land, taking care of people and sharing resources, with the aim of working all through different sectors of human activity. […] We try to reconcile engineering with architecture, with landscaping, always on these three pillars that are our ethical principles." (Mamede Santos, n.d.).

The last interviewed enterprise, Cultibaga, is situated in Santa Maria da Feira, Aveiro and concentrates on small fruit farming, with an emphasis on blueberry production with the support of modern technological innovations ("Cultibaga - Cultivo de Mirtilos Lda", n.d.). Despite the fact that the enterprise is not open for visitors, this is something that they would like to consider for the future, as they already host trainees of Young Farmers courses (Nunes, April 30 2020, online interview).

2.2 Comparison of data from the agro-businesses: differences and similarities

As you might have discerned from the presentation of interviewed stakeholders, while on the one hand, each of the six businesses is unique in the way it is structured and operated, on the other one, analogies can be drawn in terms of their relation to the

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public, their vision about sustainable and eco-friendly development and the principles that shape them. For instance, both the enterprises' target audience and scope of operations vary greatly. The target audience ranges from mainly experts in the same field and other farmers (Cultibaga, Agriplanet) to a broader approach for the general public (Ygea Farm, Terracrua Design), children, families, and educational stakeholders (Riverland Dairy Bio Farm) or even a combination of both (La Ferme Bio du Petit Sart). Regarding the scope of operations, we have examples like Cultibaga, Ygea Farm and Terracrua Design, who are active in the production of goods and the provision of agricultural services, whereas others like Riverland Dairy Bio Farm, La ferme du Petit Sart and Agriplanet combine the above with the offer of educational activities.

At the same time, one of the commonalities is that, even though not all examples of agri-businesses are open to visitors, all interviewees expressed interest in expanding to that domain through collaborations with youth organizations. This could signify a shift in the traditional relationship between producers and customers, in the sense that it has become more direct, with consumers wanting to have the experience of working at the farm and the entrepreneurs being willing to offer this opportunity. Furthermore, all six companies work utilizing sustainable and eco-friendly methodologies, having integrated these approaches to all levels of production and promoting these values to their visitors. In fact, when asked about which values and skills encountered at a farm they would like to instil to their visitors, most interviewees referred to a combination between teaching the importance of approaching agriculture in a sustainable, conscious way along with nature conservation and respect for animals, and gaining first hand training at a farm.

Another interesting outcome that arose through the interviews regards the way in which the enterprises reach out to their target audience and communicate their work. Although a couple of the agri-businesses use flyers and printed material, nowadays for the majority of them their dissemination activities take place through their social media networks and/or company website, as these methodologies render their operations more visible to a wider audience. Thus, this is indicative of the influence of technology on all aspects of an agri-business and the need of the agricultural sector to adapt to contemporary developments.

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Nonetheless, the marketing department of an agri-business is not the one where technology is most affluent and paramount. Instead, the department of production is, with all six companies having mentioned using some kind of technological equipment in their daily operations. In part, the equipment used is specialized depending of the needs and undertakings of each company. For example, Riverland Dairy Bio Farm and Ygea Farm, the only two out of the six agri-businesses producing organic eggs, use a machine for weighing, identifying the size and packaging the eggs. All in all, though, there is some standardized equipment that most of them use, in order to reduce manual labour, render their daily operations more efficient and their production greener. These include earth moving and agricultural machinery, like tractors and harvesters, weather stations that register wind speed and temperature among others, an irrigation system, a data logging system to register the above information along with the necessary software and hardware equipment, GPS stations and energy and water conservation equipment, such as water tanks or photovoltaic panels. Additionally, for livestock monitoring, farmers tend to use a feed distributing machine and microchips.

2.3 Identification of the needs of the agro-businesses

Aside from inquiring these enterprises what technological innovations they have already incorporated in their day-to-day operations, we also asked them about further tools that could facilitate their work and make it more efficient, environmentally friendly and cost-effective. Some of the needs were mentioned recurringly, whereas others were more specific, depending on the field of specialization of each enterprise.

For instance, the need for a **soil monitoring kit** was referred to by at least two partners, as such a tool would give them the opportunity to track the quality of the ground and its requirements in water and nutrients, which in turn can be beneficial for food quality and energy conservation

Another issue that came up was irrigation. While two enterprises brought up the necessity and subsequent convenience of having an **automatic irrigation system** that could also be operated remotely, a third interviewee pointed out the importance of **water conservation** and the potential benefits of the conscious exploitation of surrounding natural sources of water over the costs and environmental damage caused by water boring. Notwithstanding, upon underlining the expenses of such a venture, he proposed that projects like this ought to be supported and funded by the state and/or supranational institutions.

A third tool that could facilitate agro-entrepreneurs would be the installment of some sort of **video equipment to monitor** the facilities, the crops and the animals. This could be either cameras installed in the livestock sheds (to monitor births for example), drones flying over the fields to oversee the crops or trap cameras, equipped with sensors to track the presence of specific insects.

Two further essentials, which are directly linked to the usage and disposal or resources at an agri-business were firstly **innovations in terms of energy saving and energy conservation** that could render an agri-business self-sustaining, like triple-glazed windows, automatic shading system, solar thermal panels; and secondly, machines which **repurpose waste** into organic fertilizer, such as a composting machine to precipitate the composting process and a soil compound dispenser to facilitate the distribution of fertilizer in the fields.

Other more specific needs that were discussed refer to **tools regarding livestock**, such as a system to monitor the milking process, or **tools assisting with the public visits**, like a registration and data logging platform and installed (touch) screens at the sheds to help with the guided tours and transference of knowledge. Along these lines, the need for designing and developing an online platform for disseminating educational material was pointed out by one of the agro-entrepreneurs as a useful tool for structuring and promoting their open-to-the public activities.

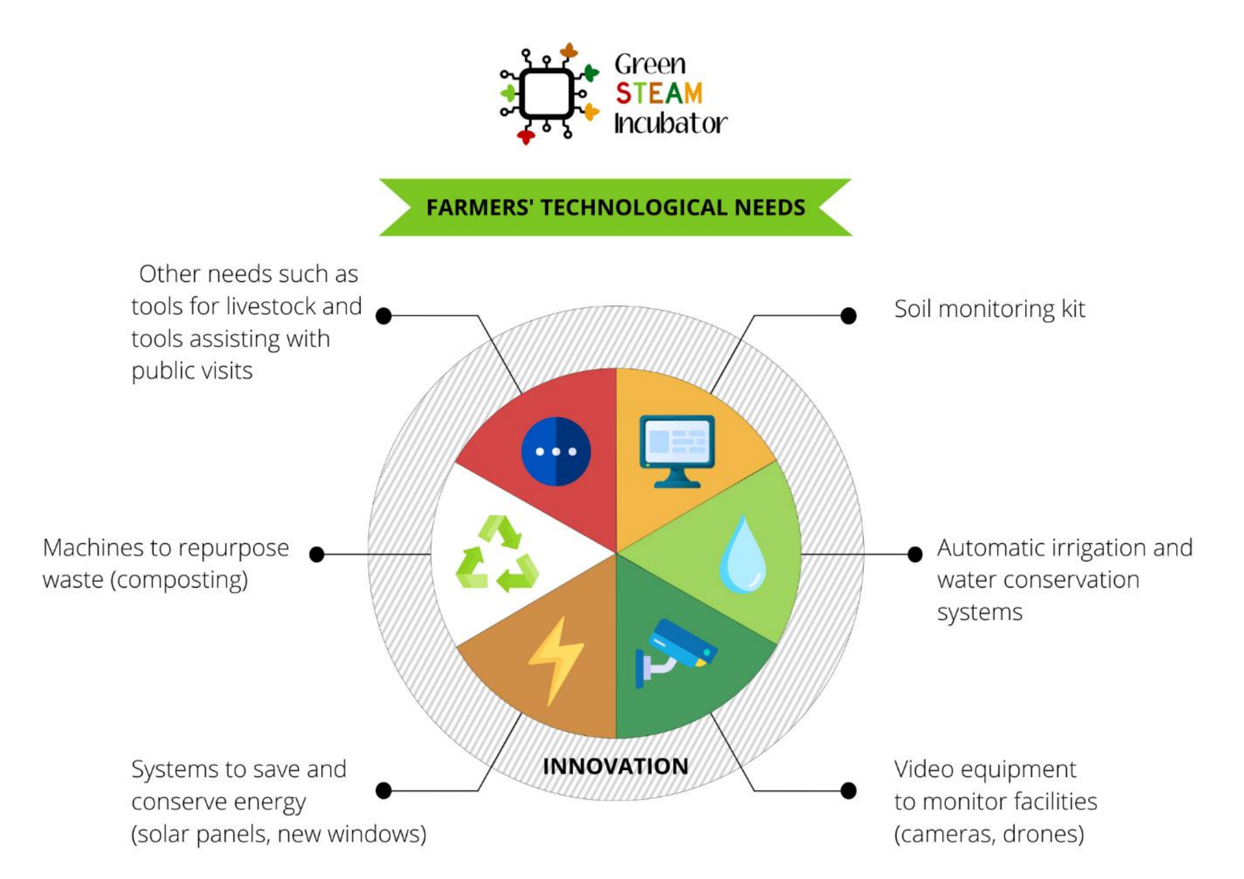

Figure 5 - Summary of the technological needs of interviewed agro-businesses

A conclusion that could be drawn from the above, is that agro-entrepreneurs are appreciative of the incorporation of technological innovations into the agricultural sector, to the point where they are even reliant on them to achieve their current production and quality standards. At the same time, the relatively low income of farmers in contrast to the expense of modern equipment, when combined with limited governmental support for more environmentally friendly solutions, as it has been expressed by some interviewees, can hold them back from investing into such ventures. As Mr Konstantinides, the owner of Ygea Farm pointed out, "New machines are always useful, but now all machines are very complicated and [come with] huge costs." (Konstantinides, May 12 2020, online interview).

Upon having identified the core needs of the six agro-enterprises, our aim through the "Green STEAM Incubator" project is to facilitate enterprises bring these to light, educate young people about them by offering the technical know-how to tackle them and even undertake creating some of the equipment on our own at a later stage in the project. Firstly though, let's explore a bit deeper why the development of collaborations between youth organizations, young people and agri-businesses is of crucial importance for humanity's future by analysing some of the challenges that farmers are facing nowadays, as well as the link between the agricultural sector and others.

CHAPTER 3

DEVELOPING COLLABORATIONS BETWEEN YOUTH ORGANIZATIONS AND AGRO-BUSINESSES

3.1 The need for developing collaborative frameworks

Challenges for young farmers

As we mentioned in Chapter 1, according to data from Eurostat in 2016, only 11% of all farm holdings in the EU are managed by farmers who are under 40 (Eurostat, 2018a). This indicates that encouraging more young people to consider their future career in farming and agriculture business is a significant challenge.

To better identify the needs of young farmers in 2015, the EU surveyed more than 2,000 farmers under 40 (Eurostat, 2018a). The findings from the survey showed that the group faces many challenges at the beginning for their professional path.

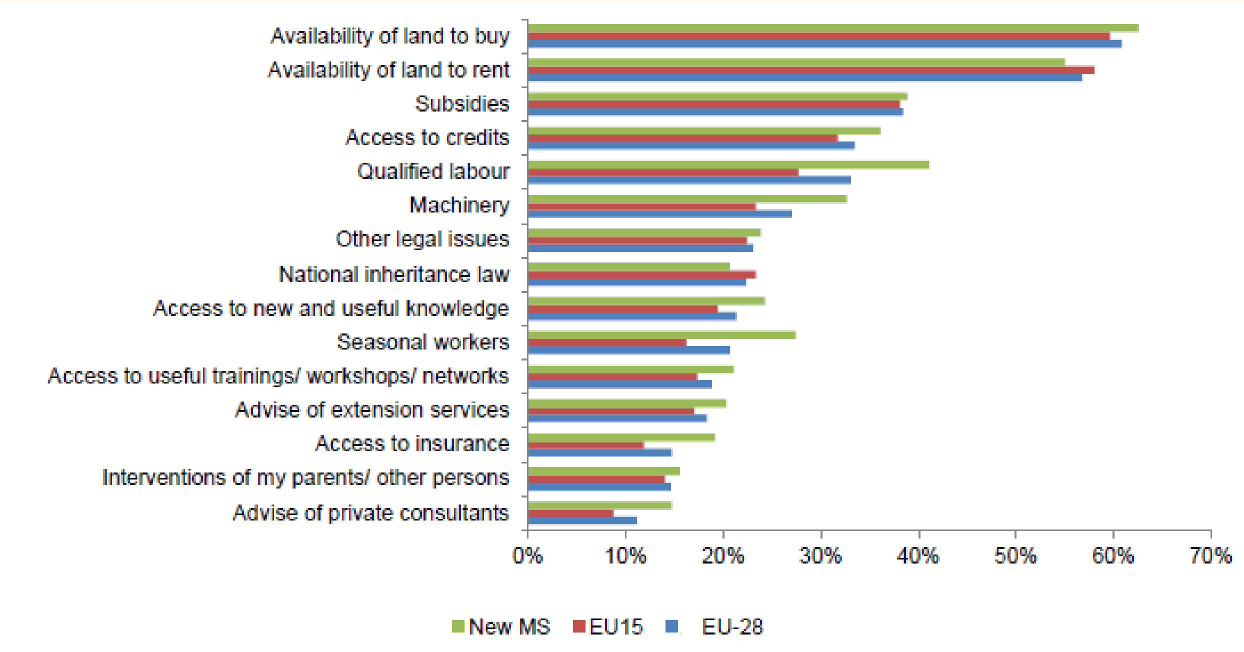

Figure 6 - General needs of young farmers in the EU (Ecorys et al., 2015, p.13)

After their studies, agronomics graduates do not usually have a significant amount of money for obtaining land, machinery, technologies, purchase orders or necessary nutrition components. They also lack the credibility needed for a bank loan. As can be seen in the findings above amongst the most essential needs of farmers are quality labour, machinery, access to new and useful knowledge, as well as access to useful trainings, workshops and networks. As can be observed in the chart below, between 2005 and 2013 the share of farmers with basic or full training increased in both age groups, but in broad terms, 62% of the youngest farmers still have practical experience only.

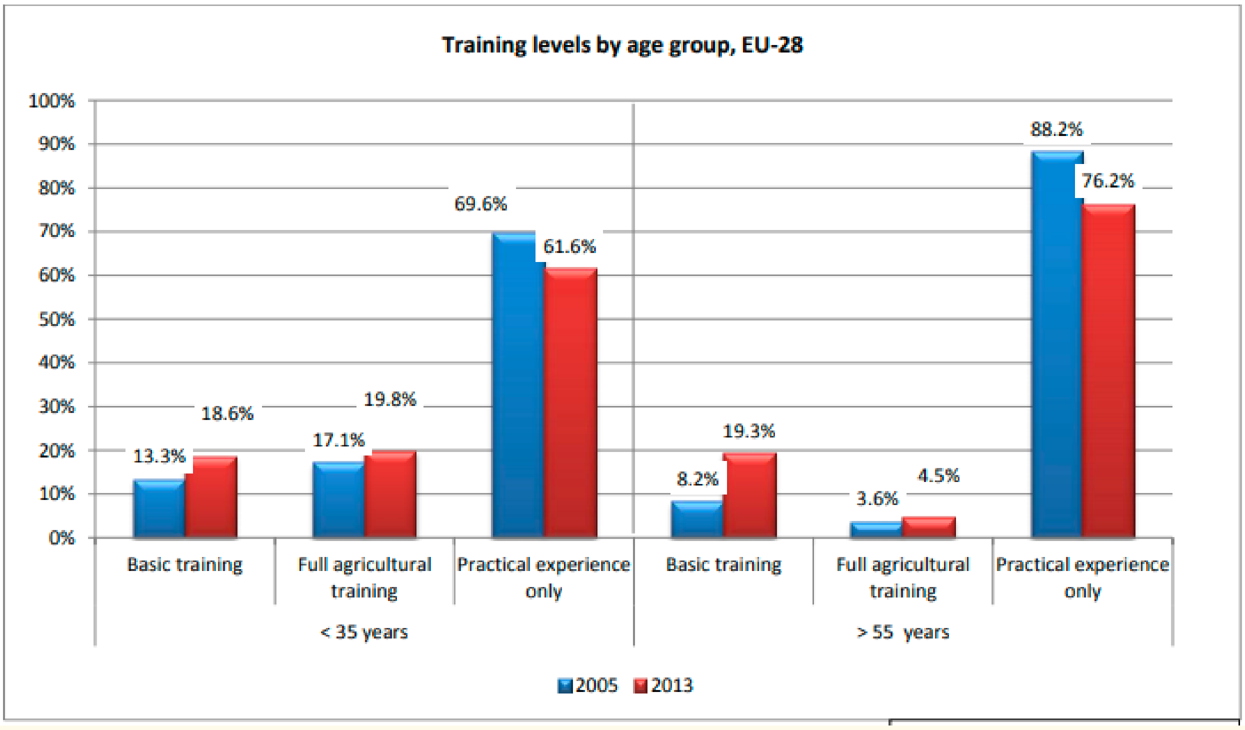

Figure 7 - Training levels by age group, EU-28 (Unit Farm Economics: DG Agriculture and Rural Development, 2017, p.7)

Indeed, to equip the next generation of farmers to face 21st century challenges, such as climate change, food shortage, waste management and distribution of water, there is a need for educational material that can help the young generation of farmers. The project Green STEAM Incubator, having detected some of the shortcomings of the agricultural field in Europe, aspires to cover some of these gaps.

Together we stand, divided we fall

As the world population continues to rise alongside with the exploration of the natural resources, there is a growing responsibility of agricultural sector to answer the food supply demand. Meeting this objective is a shared responsibility of everybody, therefore the move towards cross-sectoral collaboration and solutions is inevitable. Like the famous phrase “no man is an island” underlines the idea that human beings need to be part of a community, in order to thrive, being isolated does not bring any good.

Agricultural innovation can be driven by bringing diverse group of people together, providing a space for sharing experience, exchange on best practices and discussing what are the issues that each of the individuals are facing. Even though we live in the era where Internet is one of the main sources of information for young farmers there is nothing that can replace a hands-on experience. As data from the before mentioned EU survey shows over 70% of interviewed young farmers are mentioning farm visits/fairs/workshops and courses as a main source of knowledge.

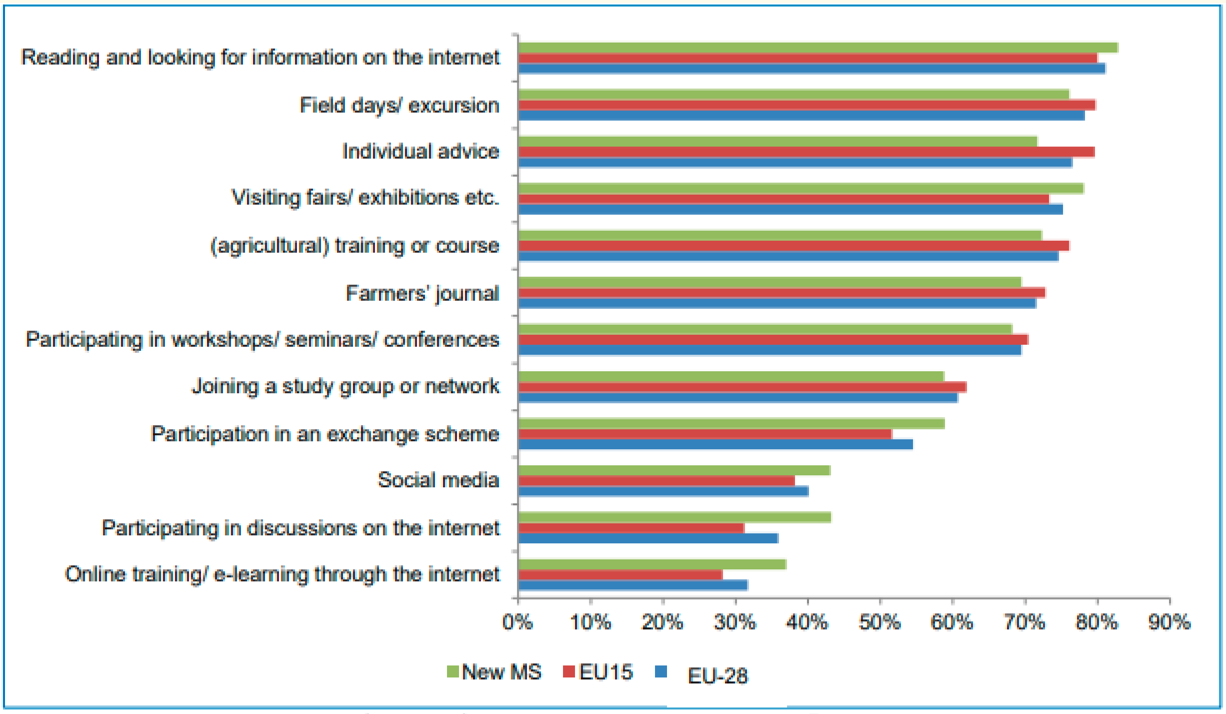

Figure 8 - Percentage of interviewed young farmers using the below knowledge

(Ecorys et al., 2015, p. 19)

Setting a framework and providing inspiration on how to create collaborative affiliations among youth organizations, relevant stakeholders and agro-businesses lies in the heart of the Green STEAM project goals. By designing and delivering Modules for “Microcontrollers” and “3D Modelling”, Youth Laboratories (Incubators) partners will enable the participants to acquire knowledge on how to design and promote holistic, high-tech solutions for sustainable communities.

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As one of the objectives of European Commission's Common Agricultural Policy (CAP) is to increase competitiveness by triggering productivity, this fusion between technology and farming is helping farmers to maximize production, while minimizing costs and resource drain (European Commision, n.d). These new challenges bring new opportunities and provide a space for interaction between young farmers, scientists, producers and technology experts, thus allowing for the development of innovative solutions to address practical needs.

3.2 STEM curriculum

After having presented the background against which the project was developed and the necessity of the project, it is time to detail the key concepts that Green STEAM Incubator is based upon!

What is STEM education?

First and foremost, STEM is an acronym that stands for "**Science, Technology, Engineering and Mathematics**". It concerns the ensemble of these fields, and the connected skills and knowledge, which are widely sought after in the professional scene.

In the academic sense, STEM can also designate the combined interdisciplinary approach to all these disciplines through an interconnected curriculum based on real-world applications. STEM education is thus the approach that combines all these academic fields; Science, Technology, Engineering and Mathematics, into one cohesive and interconnected learning.

While the demand for STEM fields is ever growing on the professional plane, students have shown an increasing tendency to turn their back on those subjects in school for many years. Recent PISA studies (OECD, 2018) have shown that EU education system is still insufficient in the STEM field. European students who are low achievers in Mathematics amount to 22.4%, where as those who perform low in Science are 21.6%. As a result, one out of five youngsters in Europe is not equipped with the basic skills necessary for numerous valuable jobs in our current economy. Despite the fact that only 4 EU countries in terms of Science and 3 countries in terms of Mathematics (including Finland, who that is right on the benchmark) have a lower underachievement than the benchmark of 15% fixed by the EU, the problem of reaching a basic level on STEM is still of critical and of transnational importance. Sentences such as "I am no good at Math", or "We will never use any of that stuff, we have Google" are becoming common place in the school halls.

Different reasons are stated for this phenomenon. The increased complexity of the STEM subjects and higher standards demanded at a younger age may be a part of it, but several scholars, such as Pr Kouider Ben-Naoum, enunciate that the problem lies in the absence of contextualisation of these subjects and the academic approach that is currently mainly theory-based and compartmentalized. An indication of this is the sudden decrease in interest for STEM subjects usually occuring in high school, when the subjects gain in complexity, become even more abstract and lose in concrete applications demonstrated in class. In reaction to this decrease in interest, governments, and European institutions decided to launch initiatives to boost STEM education both on a European and national level. Examples:

STEM Alliance brings together Industries, Ministries of Education and education stakeholders to inspire the next generation of researchers and industry professionals in STEM field.

Figure 9 - Logo of Stem Alliance (Homepage, n.d. b)

Scientix is a European network for people working in the Science field of education, which helps to create a flow of information about all the new developments that are taking place in the STEM field and provides a database of resources.

Figure 10 - Logo of Scientix (Homepage, n.d. c)

These initiatives rely on the combined STEM approach that aims at interconnecting the different fields, in order to increase the context and stimulate interest into the subjects by showing the applicability of different subjects into other fields and into real-world situations.

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Why is STEM education so important?

In a world where scientific advances are always occurring increasingly faster and in which technology, science, engineering, and mathematics are so prominent for today's careers, there is a growing need for STEM-skilled workforce. Around 7 million job openings are forecastes until 2025 (EMPL Committee Study, 2015). However, the decrease of interest in STEM leads to the discouragement of students and failure of those following a STEM-oriented curriculum in higher education, as it's showed in the previously mentioned PISA results. STEM education is important, not only for boosting the students into STEM careers, but also, for allowing an integrative teaching style that in fact fosters a wide spectrum of competences such as:

- problem solving
- creativity
- critical analysis
- teamwork
- independent thinking
- initiative
- communication
- digital literacy

as well as critical thinking, inquiry skills, scientific practices, argumentation skills, modeling skills, critical and higher-order thinking, critical dispositions, and others.

As most learning nowadays is inquiry-based, pupils are much more attuned to resolving life-problems, to think out of the box and to see the big picture. STEM education aims at active learning much more than passive learning. Many academic papers and global reports, such as the "Mathematics Education in Europe: Common Challenges and National Policies" from the Eurydice network (2011), point out the importance of the learner's motivation and engagement. For example, an architect will need Science, Mathematics, Technology and Engineering daily to create sustainable buildings. The combined approach of STEM education allows to show students how all of these disciplines are not separate things, but complementary and supportive of each other in a lot of real-life situations.

Finally, STEM education aims at encouraging students that are more inclined to be discouraged in pursuing a STEM career, like those who come from a disadvantaged economical background or students with specific learning disorders. There is also a great number of initiatives to motivate female to join the STEM industry. As data from Eurostat shows (2019), in 2017 out of the 17.6 million scientists and engineers in the EU, 59% were men and 41% women.

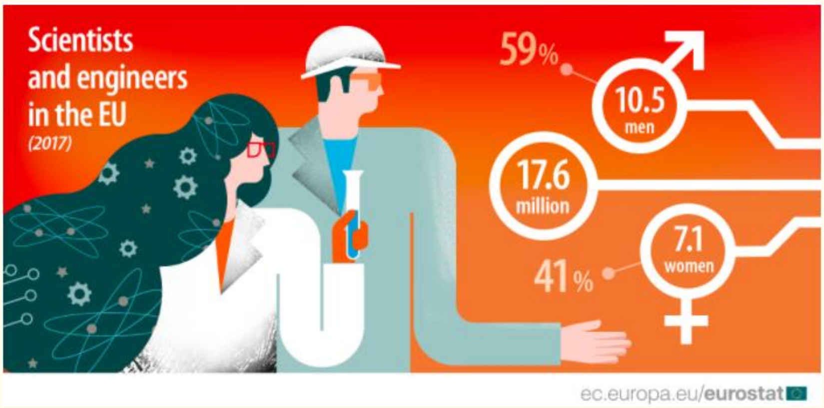

Figure 11 - Scientists and engineers in the EU (Eurostat, 2019b)

How is STEM related to agriculture?

The field of agriculture allows for a multitude of links between the STEM curriculum. According to the Oxford Languages Dictionary, agriculture is “the science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, wool, and other products.” (quoted in Education WA, 2019). But how is it related to STEM? Let us go discipline by discipline and see how all STEM subjects intersect with agriculture.

Science

Science is a discipline that gathers several subdisciplines, such as physics, chemistry, biology, nutrition among others. Here the discipline that will approach first is Biology, meaning the study of living organisms (Science Direct, 2019). Agriculture is basically the science of growing plants and raising animals, with the vision of producing edible plants and animals or plants and animals that are usable by humans in several fields; for example, nutrition but also pharmaceuticals, perfume industry, energy field, cosmetics, or even simply building (wood).

- **Biology** is essential to understand the way that the targeted organisms evolve, their needs and their production process.
- **Chemistry** is the study of matter and its composition, which is also needed in agriculture both in order to maximize its production and to understand basic living processes, such as photosynthesis for plants, composting and soil composition.
- **Physics**, the study of matter, motion and energy, will also come into play by mapping fields and being aware of gravity factors and water dynamics, in order to have the best efficiency in growing plants or installing a farming system.

Technology:

Nowadays, every field has its own need for technology, with agriculture being no exception. Machinery is one of the keys to mass production that we need in terms of food, due to planetary over population. Furthermore, technology is nowadays used to monitor the fields, and in research, to find plants that are more resilient and more productive. Some plants are even engineered, or reverse engineered to, either create a variety, or to bring back an old variety to life.

Engineering:

As stated above, plants can be engineered or reverse engineered, but that is not all. Engineering comes in handy in the production chain, and in the setting up of the farming system structure. There is a particular branch of agriculture called **agriculture engineering** that deals with the “design of farm machinery, the design of the farm drainage, soil management and erosion control, water supply and irrigation, rural electrification, and the processing of farm products (Webster, 2020). It is using all the aspects of Physics and designs them into complex farming systems that are thought of with efficiency in mind.

Mathematics:

Not only are Mathematics useful to other disciplines, but they can also be necessary in the context of agriculture. Indeed, Mathematics are needed even in simple ways, such as calculating the square footage of a plot of land that you intend to plant. Additionally, Mathematics are needed whenever production calculations are to be

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carried out, be it watering needs per square meter, fertilizer needs per square meter, time and resources needed per kilo of produce, etc. Mathematics also come into play into all previous disciplines; Science, Technology, and Engineering as well in a plethora of ways.

All these disciplines are brought about into the field of agriculture and are very much entrenched into concrete applications. Agriculture allows us to both delve deep into concrete STEM applications, but also to touch concepts of sustainability, climate awareness, and demonstrate the need for out-of-the-box thinking and problem-solving.

The field of agriculture is an ideal playground to understand the interconnectivity of STEM subjects and their importance in today's society. Let us dive deeper in the main concepts that can allow that correlation.

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SCIENCE

Environmental conservation and sustainability

Environmental conservation's objective is to preserve the fragile ecosystem that we live in from pollution and degradation and extinction of species (Ramanik P., Sharma D.K., Maity A., 2014). The reasons behind the fusion of environmental conservation and sustainability are to conserve natural resources and to develop alternate sources of power in a more energy efficient and protective way. Sustainable development encourages projects that can reduce impacts (environmental, financial), but sometimes it is more difficult to keep things balanced. Nowadays, the most serious issue is that the growing industrialization of our society is undermining most of environmental sustainability endeavors (Conserve Energy Future, 2020).

With growing awareness of the environmental damage caused by intensive cultivation, the academia agrees that ecological farming should be a priority. More eco-friendly and sustainable farming solutions are strongly recommended to prevent future damage. **The top 5 sustainable and eco-friendly farming practices are:**

- Permaculture
- Aquaponics and hydroponics
- The use of renewable energy resources
- Crop rotation and polycultures
- Planting trees to increase crop yields.

To prevent the inevitable scarcity of water, more efficient water management in agriculture is essential. Soon, farmers could be able to use rainwater completely and efficiently by practicing conservation tillage, regular weeding and the construction of vegetal barriers and earth dams (Socratic, 2018). Trees, bushes, and hedges should also be replanted around fields. The topography must be taken under consideration, in order to take advantage of the natural distribution of lands.

According to the Food and Agriculture Organization of the United Nations, women make up 43% of the agricultural workforce (FAO, 2020), but because of limited access to tools, land, and services, they produce less per unit of land than men. It is therefore crucial to invest in their training and support.

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Policy reformers should take into account the knowledge and solutions proposition of people working daily in agriculture. Sometimes, the ever-evolving way of life we tend to have, should be slowed down to give space to older practices that are more respectful of the environment. By opting for environmentally friendly techniques, natural resources could become protected in the long term.

Renewable energy resources

In both urban and rural areas, as well as in developing and industrialized countries, the use of renewable energy has become increasingly important. All over the world, the need for sustainable energy development is increasing. This must be a priority, especially in view of the adverse environmental effects of the use of fossil fuels. (EDF Energy, n.d.)

Not all renewable energy resources are intrinsically clean. Nevertheless, the use of renewable energy resources can almost certainly provide a cleaner and more sustainable energy system. The small scale of equipment required often reduces the time from initial design to operation, allowing for greater adaptability to meet unpredictable changes in energy demand. Renewable energy sources may be carried out according to the climate of the country in which it is planned to be implemented. For example, in Cyprus, solar energy is suitable for sustainable energy development.

The most popular renewable energy sources currently are (WikiHow, 2020):

- Solar energy
- Wind energy
- Hydro energy
- Biomass energy
- Geothermal energy

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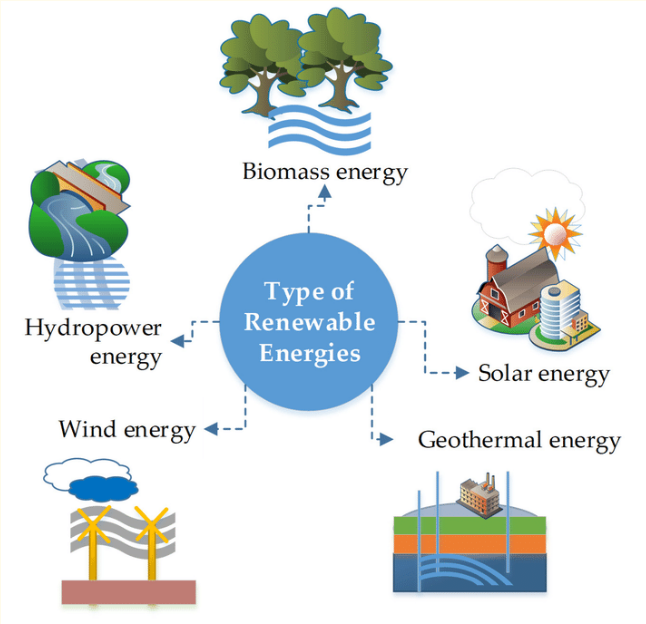

Figure 12 - Types of renewable energy resources (Avrat et al., 2019)

Sustainable agriculture involves the use of alternative energy sources (Duval, 2017). Solar panels can be used to operate pumping and heating systems. In addition, hydroelectric power from river water can be used for various agricultural machinery. Introducing renewable energy into the agricultural process can lead to higher results and lower environmental impact while keeping low costs of production.

Keyline system

In the 1950s, the Australian farmer and engineer P. A. Yeomans invented and developed keyline design through several literary works. He described a contour amplification system of the land to control rainfall runoff and allow rapid irrigation without the need for terracing. (Possible Media, 2015)

This landscaping technique, therefore, consists of optimizing the use of water resources of a patch by using natural topographical features and technical flow arrangements through demarcation lines.

Irrigation dams can be created and equipped with pipe systems to allow gravity irrigation, reserve water and yard water. Graduated earth channels can be connected to each other to widen the catchment areas of high dams, conserve water height and transfer rainfall runoff to the most efficient high dam sites. Roads follow both ridges and water channels to facilitate travel across the land. (Crkeyline, n.d.)

David Holmgren has used Yeoman's concept in creating his own principles for permaculture and the design of sustainable human settlements and organic farms. (“Permaculture”, 2020)

Keyline water management has the potential to enhance the water efficiency of any production system. Applications can include (“Keyline system”, 2020):

- pastured livestock & grass farming
- agro-forestry & forestry layout
- orchard layout
- silvo-pasture layout
- alley cropping layout
- annual vegetable production
- ecological restoration
- watershed planning & management
- urban planning (new developments)

Subsoil grubbing and agroforestry techniques have been applied in all major ecosystems. They have been applied to many different producers.

Here are a few examples among many: In Australia, there is a keyline agro-forestry layout. In Sweden, there is a keyline-inspired farm (Ridgedale Permaculture, n.d.). Keyline subsoil ripping takes place every year as part of a water management system in Wisconsin, United States. A keyline-inspired farm in Oaxaca, Mexico integrates perennials, annual cash crops and animals.

Figure 13 - Keyline subsoil ripping takes place every year as part of a water management system (Crkeyline, n.d.)

Organic agriculture and organic farming

Organic farming is an agricultural method that aims to provide food using natural substances and processes (FAO, 2018). This suggests that organic farming tends to have a limited environmental impact, because it encourages:

- the responsible use of energy and natural resources,
- the upkeep of biodiversity,
- the preservation of regional ecological balances,
- the enhancement of soil fertility,
- the maintenance of water quality.

Additionally, organic farming rules advocate a high standard of animal welfare and require farmers to meet the specific behavioral needs of animals.

Figure 14 - Organic sector in the European Union (European Commission, 2018a)

European Union regulations on organic farming are designed to provide a clear structure for the production of organic goods across the whole of the EU. This is to satisfy consumer demand for trustworthy organic products, whilst providing a fair marketplace for producers, distributors, and marketers. (HortDaily, 2019)

Different modes of production have been put into place by farmers, who are concerned about their families' well-being and the current agricultural economy. Organic agriculture is a means of enhancing food security and reducing costs. More and more self-sufficient farmers are using direct channels to distribute organic and non-organic products to consumers.

Permaculture and differences with organic farming

While organic farming promotes the use of the natural fertilizers, so that waste from plants transforms into food (fertilizer) for another, permaculture not only uses organic farming practices, but also goes one step further. It is a set of practices that creates a lifestyle with less impact on the environment.

Permaculture is a method of food production that aims to imitate nature and applies natural principles, such as soil and water conservation, less ploughing and more intricated ways of planting. Letting vegetables and plants grow in a system resembling natural ecosystems, designed to reduce waste of resources and increase production efficiency, makes permaculture a real asset for future farming technique. Permaculture also puts the consumer's waste back into the cycle of production and brings food

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directly in the nearest areas, preventing wasted energy in the transportation process. (Permaculture Vision, 2018)

Common practices of permaculture are:

- **Agroforestry** - a land control system in which trees or shrubs are grown around or among crop fields or pastures.
- **Hügelkultur** - a horticultural method of planting mounds of decaying wood chips and other compostable plant materials in the form of biomass to form a raised bed.
- **Natural building** - using a range of building systems and materials that emphasise sustainability.
- **Rainwater harvesting** - the collection and storage of rain, rather than letting it run off.
- **Sheet mulching** - a cold composting method that attempts to mimic the natural soil-building process in nature.
- **Grazing** - a farming practice that allows livestock to consume vegetation outdoors to transform grass and other fodder into animal products, often on land unsuitable for crops.
- **Keyline design** - a landscaping technique of maximizing the beneficial use of the water resources of a tract of land.
- **Fruit tree management**
- **Marine Permaculture** - a form of agriculture that recreates the habitat of algae forests and other ecosystems in near-shore and offshore ocean environments.

Biodiversity

Biodiversity is the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention sur la diversité biologique, 2004).

This ongoing biological variability allows living organisms to adapt to variations in ecological conditions or relationships with other organisms. Natural selection

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processes allow the survival and the reproduction of individuals most adapted to the environment.

Biodiversity plays an important role in ecosystem functions that provide supporting, provisioning, regulating services (e.g. nutrients, water cycling, soil formation, resistance, pollination, regulation of climate, as well as pest and pollution control). Local or functional extinction, or the reduction of populations to the point that they no longer contribute to ecosystem functioning, can have dramatic impacts on ecosystem services (European Commission, 2018b).

Habitat conservation

Habitat conservation is the practice of protecting, restoring habitats and preventing the extinction, fragmentation, or reduction in the distribution of species. It is a priority for many groups active in environmental protection around the world, and maintaining biodiversity is a key issue in habitat conservation. This in turn raises the issue of global food security. There is evidence that the erosion of genetic resources of agricultural plants and animals is accelerating, and the genetic similarity of agricultural plants and animals is increasing, which means a growing risk of food loss in the event of major epidemics (Green Facts, 2020). The most important conservation organisations currently in operation are: The Nature Conservancy, World Wildlife Fund (WWF), Rare Conservation, and other organisations. Some of the solutions proposed by these organizations to maintain plant diversity for food security purposes are a combination of seed banks and habitat conservation.

To help farmers understand the stakes and make the concept applicable to their exploitations, some European organisations have taken into their hands to give on-farm conservation advisory services based on partnership and mutual learning. The farmer and the advisory team enter into dialogue and carry out an analysis of the situation of the entire farm and the surrounding landscape.

Some of the solutions to be considered are to use some meadows that are rich in species to raise cattle; a more efficient management of the lands with sustainable grazing models and respect of the biodiversity and ecosystems of specific areas (e.g., insects, mammals, flowers); also to create labels that promote such initiatives and encourage consumers to take action in their consumption. ("Habitat Conservation", 2020).

TECHNOLOGY

As it has been analysed above, agriculture is of extreme importance for the life of human beings, since it is one of the main sources of food and raw materials. Agriculture has undergone several changes over the years. Today, it is in the era of the technological and digital revolution. Technological advances in agriculture have made it possible to get around the existing difficulties that the lack of manpower poses and, at the same time, allowed for an increase in productivity (Gondchawan & Kawitkan, 2016) (Jawad et al., 2017).

In recent years, the human approach towards agriculture has been one of the causes of water pollution and soil erosion, mainly due to the use of pesticides and chemical fertilisers. Therefore, one of the major challenges for agriculture is the sustainable use of resources. In other words, agricultural production needs to produce the right quantities, at the right time and with the use of controlled resources appropriate to each crop, such as the amount of water needed in order to avoid waste. To achieve the goal of sustainability and preservation of the environment, agriculture had to resort to technology (Gondchawan & Kawitkan, 2016) (Jawad et al., 2017).

Precision farming uses the latest technology to monitor and act on crops in order to obtain solutions to the following problems: reducing the use of pesticides and chemical fertilizers; reducing the ecological footprint; increasing the quantity and quality of production; reducing production costs; ensuring crop information (Gondchawan & Kawitkan, 2016) (Jawad et al., 2017).

To achieve the objectives described above, **wireless network systems** – namely, **Geographic Information Systems** (GIS) and **Global Positioning System** (GPS) –, automation and **Internet of Things** (IoT) technologies, microcontrollers and three-dimensional modelling or three-dimensional modelling are used.

GIS is an application that enables us to associate concepts like spatial information with alphanumeric information (Tristany & Coelho, 2003). In agriculture, GIS are increasingly used for planning and management at two different levels: regional and farm; they can be used for tasks like management of irrigation perimeters, maps of agricultural potential, studies and projects for parcelling and farm management (AJAP/Agri-Ciência, 2004). Their use is crucial, since most of the technologies that serve as the basis for these systems need georeferenced information, and they are able to store, analyse and present information (AJAP/Agri-Ciência, 2004). In fact, it is the integration of GIS with other technologies, such as GPS, that makes it possible to create a complex data structure, which underpins most of the technological systems applied to agriculture.

The **GPS** is a positioning system that is used to determine the location of an object on the Earth's surface or in the air. It is used in agriculture because it has the function of determining the spatial variability of a crop (AJAP/Agri- Ciência, 2004), for example. The GPS is divided into two distinct components: a satellite system and a signal receiver in the user (AJAP/Agri- Ciência, 2004).

IoT is defined by the Internet Society as "the extent of network connectivity and computing power for objects, devices, sensors and other artefacts that are not normally considered computers" (Centro Nacional de Cibersegurança PORTUGAL, 2017). IoT "comprises all devices and objects that are enabled to be permanently connected to the Internet, being able to identify themselves on the network and communicate with each other" (Centro Nacional de Cibersegurança PORTUGAL, 2017).

In addition to the technologies mentioned in the previous paragraph, **microcontrollers** and **three-dimensional modelling** are important tools for today's agriculture, as they help with automation and the printing of tailored agricultural tools, and because they are a substantial component of the Green STEAM Incubator's methodology. Let us understand what they consist of.

A **microcontroller** is a miniature computer, which contains a single integrated circuit with a processor core, memory and programmable input and output peripherals. The programming memory can be RAM, NOR flash or ROM, which is often included on the chip. Microcontrollers are widely used in technological equipment for monitoring weather conditions, for example.

On the other hand, **three-dimensional modelling** consists of the mathematical representation of an object, which can be alive or inanimate, through specialized software. In agriculture, three-dimensional modelling is used in the reconstruction of plants in 3D, allowing to understand the characteristics of the plants, to detect diseases, to evaluate the quality of the crop and to differentiate between weeds and plants (Centro Nacional de Cibersegurança PORTUGAL, 2017).

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Precision farming is based on the analysis of the growing environment, using temperature, humidity and conductivity sensors, among others. These are used in order to obtain information on the variables in different cultivation sites. After gathering all the information, the farmer can decide what action to take, i.e. understand what the real needs of the crops are and act accordingly, such as increasing or decreasing the watering of crops, and applying fertiliser depending on the nutrients lacking in the soil. Acting according to the needs of the crops allows to use the resources sustainably and avoid unnecessary use of the resources (Gondchawan & Kawitkan, 2016) (Jawad et al., 2017).

In the following pages, we will analyse the importance and how technology is used in agriculture and livestock breeding, namely through innovative tools like temperature and weather monitoring, soil monitoring, data logging systems (software), earth moving and agricultural machinery, composting and soil distribution machines, automatic irrigation systems, energy and water harvesting systems as well as livestock farming tools.

Temperature and weather monitoring

First of all, we will analyse the importance of weather conditions for crops. Weather conditions suitable for a culture allow it to develop in a healthy way and with the expected performances. For the development of a plant, it is paramount that the ambient temperature is not too different from the temperature of the plant root. Otherwise, the plant will become weaker and partial or even total leaf fall may occur. In other words, temperature monitoring makes it possible to understand the thermal needs of the crops to develop properly, both in terms of quality and quantity. There are different types of equipment to monitor temperature (Novais, 2015).

There is the simple digital monitor, which is usually equipped with a fast response sensor, capable of ensuring compliance with quality assurance and energy efficiency systems. The reading through this type of sensor stabilizes quickly after its insertion. The temperature monitor has fast response sensors, which can generate readings quickly, a range of alternative sensors, which allows the creation of a complete monitoring system and, finally, a coupling connector, which has the function of preventing accidental disconnection during use.

Another equipment for wireless temperature monitoring is a system called Barn Owl for crop storage. This system has the particularity that the installation of software is not necessary, since it is a web-based system. The wireless radio transmitters are connected to the sensors and no manual temperature measurement is required, the system allows to record the temperatures and provides the possibility of their respective reading online. Another advantage of this system is that it allows the independent control of fans, which provides greater energy cost savings.

As mentioned earlier, weather conditions have a major influence on crop productivity and quality. The most used tool to analyze these conditions is weather stations, which are a piece of equipment that monitors and characterizes the climatic conditions. The weather conditions that most influence crops are air and soil temperature, wind, soil moisture, atmospheric pressure, rainfall. They consist of two main categories of equipment: sensors and central recorders. The sensors translate physical events into electrical and electronic signals and are responsible for quantifying several meteorological parameters, such as precipitation, relative humidity, air temperature, wind speed and direction, solar radiation (incident and reflected) and atmospheric pressure. Automatic weather stations usually operate with a central recorder, called a data logger, which stores sensor readings and can also transmit the recorded data to a platform or web browser. Weather stations are powered by rechargeable batteries and/or solar panels (Braga et al., 2011).

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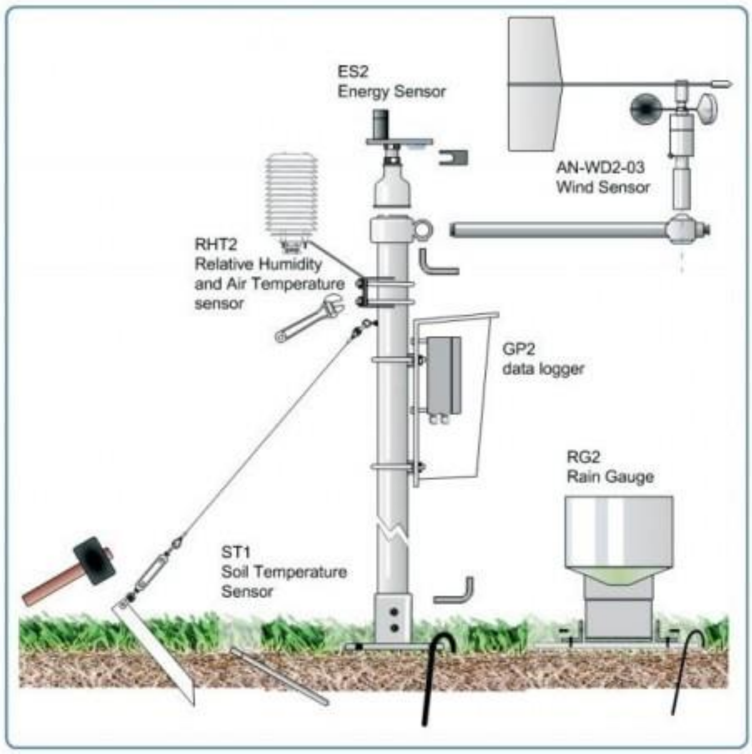

Figure 15 - WS-GP2 Advanced Automatic Weather Station System (Alphaomega Electronics, n.d.)

Weather stations, which play a key role in today's agriculture, allow not only to estimate the crop's water needs but also the risk of diseases and pests (Braga et al, 2011).

Soil monitoring

Besides the weather conditions, soil is fundamental to agriculture since it is its substrate. The main functions of soil are to be the germination environment, to support the roots and to be the nutrient dilution medium. Plants obtain their nutrients from the mineral components in the soil. The proper concentration of these nutrients is of extreme importance for the development of a plant (Novais, 2015).

Often the soil is not able to provide all the nutrients necessary for the development of a plant, which leads to decreased productivity and quality, as well as exposing plants to a higher risk of diseases and pests. The identification of nutritional needs is fundamental to start the treatment and to avoid loss in production and food quality. Today, the nutritional needs of plants can be met using fertilisers, which can be chemical or natural. The use of fertilizers according to the nutritional needs of the plants allows better management of resources and the environment (Novais, 2015). However, in practices like permaculture, fertilizers are not advisable.

One way to understand the nutritional needs of a soil is to perform soil analysis. Soil analyses evaluate fertility and pH. Fertility refers to the presence of macronutrients and micronutrients.

Macronutrients	Micronutrients
• Carbon • Oxygen • Hydrogen • Nitrogen • Potassium • Phosphorus • Calcium • Magnesium • Sulphur	• Iron • Manganese • Boron • Zinc • Copper • Molybdenum • Chlorine.

The difference between macronutrients and micronutrients is not based on the degree of importance, because all nutrients are equally indispensable and are all essential for the development of a plant. The difference between macronutrients and micronutrients consists of the number of macronutrients needed for plant development. That is, plants need large amounts of macronutrients and smaller amounts of micronutrients. The pH is important to analyse because it is directly related to the availability of most nutrients (AJAP/Agri-Ciência, 2004) (Faquin, 2005).

In Precision Agriculture systems it is necessary to know the spatial variability of soil characteristics, so it is crucial to take and analyze several samples, being essential to determine their precise location. It is necessary to use a GPS to determine where the samples were taken, to make the exact correspondence of each soil analysis. The results are used to create fertility maps (in GIS) to individualize the needs (AJAP/Agri-Ciência, 2004).

For domestic farmers, there are now mobile phone applications that can diagnose the nutritional needs of plants, pest damage and/or disease from a photo of the plant. In addition to this, the application makes recommendations for treatment and possible preventive measures. The treatment suggestions can be conventional or organic. Here are some examples of these applications, which can be free or low cost:

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- Plantix: this is an application that offers farmers guidance and advice on how to deal with diseases and pests that affect their crops;

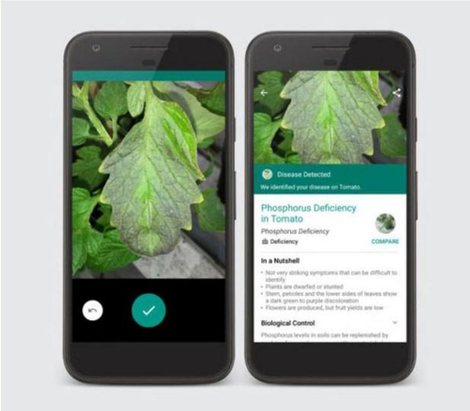

Figure 16 - Plantix Mobile Phone Application. (Fubbá, 2020)

- Meteobot: updated every ten minutes, this application gives farmers real-time information about the weather and soil conditions;
- AgriSync: this application helps to connect farmers and advisors to resolve any problem, in real-time, via video.

In addition, crops need substrate and water. Water is supplied to crops through rain and/or irrigation. Understanding the water needs of plants is also extremely important for their development. Excess and/or deficit water requirements lead to decreased productivity and quality, leaving plants more vulnerable to diseases and pests.

Soil moisture monitoring has long been used in agriculture as an effective method of measuring the efficiency of irrigation and water use by the plant. Moisture monitoring can be carried out using soil moisture probes. This type of equipment not only monitors soil moisture but also soil salinity and temperature.

A good example is the T_SOIL soil moisture probes, that have a system that can be configured to the farmer's needs using "high-precision capacitive sensors with several independent sensors to monitor the soil moisture content at various depths, every 10 cm, up to a maximum of 150 cm" (Agriterra, 2020, online interview). Soil moisture readings are taken every 30 minutes and communication between Datalogger is established every 3 hours. "The system may include a volumetric meter or rain gauge, depending on the type of irrigation system (drip or sprinkler), which allows the

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detection of problems in the irrigation system, such as lack of uniformity in irrigation areas and pressure problems or blockages" (Agriterra, 2020, online interview).

The T_SOIL monitoring station integrates soil moisture sensors (at various depths) as well as soil temperature sensors (at various depths). It is a data acquisition datalogger and has a GPRS communication system and an autonomous power system. It has endowment mediation equipment next to the probe (volumetric meter/Pluviometer) and provides access to uSENS V3.0 software as well as continuous access to data from all sensors. It allows the crossing of all kinds of information from the sensors in function for export to Excel file (Agriterra, 2020).

Figure 17 - T_Soil monitoring station (Agriterra, 2020)

Data logging systems

New technologies are now found in all areas of the agricultural sector, from soil analysis to effective plant growth monitoring at all stages. Providing precise recommendations on field treatment, helping with documentation, showing maps of agricultural land, monitoring climate risks. All these resources are integrated into a data logging system called **farm management software**. Therefore, nowadays, no professional farmer can do without technological aids in the management of his/her business. The farm management software assists in daily decision making, task planning and control and in defining the most appropriate organizational strategies. This tool has allowed the growth of agricultural enterprises (AJAP/Agri-Ciência, 2004).

The use of this tool in agricultural management helps "the producer at various stages of production ranging from control of the area planted, land productivity and harvest planning" (Machado, 2018). "The management software facilitates the tasks [...] of agribusiness management, optimizing the efficiency of processes" (Machado, 2018), such as reducing production costs, increasing productivity and improving the quality of agricultural products.

There are several data logging systems on the market; the choice of software depends on the functions provided by the software with the desired features. However, some features should provide as much information as possible, that everyone should have, be accessible online, be easy and fast to use, allow cooperative work and be cost-effective (AJAP/Agri-Ciência, 2004) (Machado, 2018).

Earthmoving and agricultural machinery

As it has been said above, soil plays a fundamental role in the development of plants. Good soil has the function of providing water, oxygen and nutrients. Therefore, a well-prepared soil is fundamental for the development of a crop. **Land movement**, which is a system of soil preparation, enables certain agronomic objectives to be achieved. Its objectives are to improve the physical properties of the soil, favour the germination of seeds, promote the reserve of water and nutrients, favour the size and shape of suitable products, promote the health of the crop and promote good soil drainage (acientistaagricola, 2018).

The use of mechanical tools, also known as **agricultural machinery**, is necessary for handling as well as other agricultural tasks. Different types of agricultural machinery are used in agriculture. The most used are **tractors, tillage implements, sowing machines and transplanter machines**. Tractors have the function of pushing and pulling equipment, namely equipment that ploughs the land. Tillage implements help to prepare the soil for planting, loosen competing weeds and/or plants. The most used sowing machines are called planters, which, as the name suggests, are used for sowing. This machine is usually used towed behind a tractor and has the function of spreading the seeds evenly through the soil in long rows. And finally, transplanters which have the function of helping in the transplantation of the plant.

Figure 18 - Agricultural machinery: tractor working the soil (Acientistaagricola, 2018)

Figure 19 - Tillage implements (University of Minnesota, 2018)

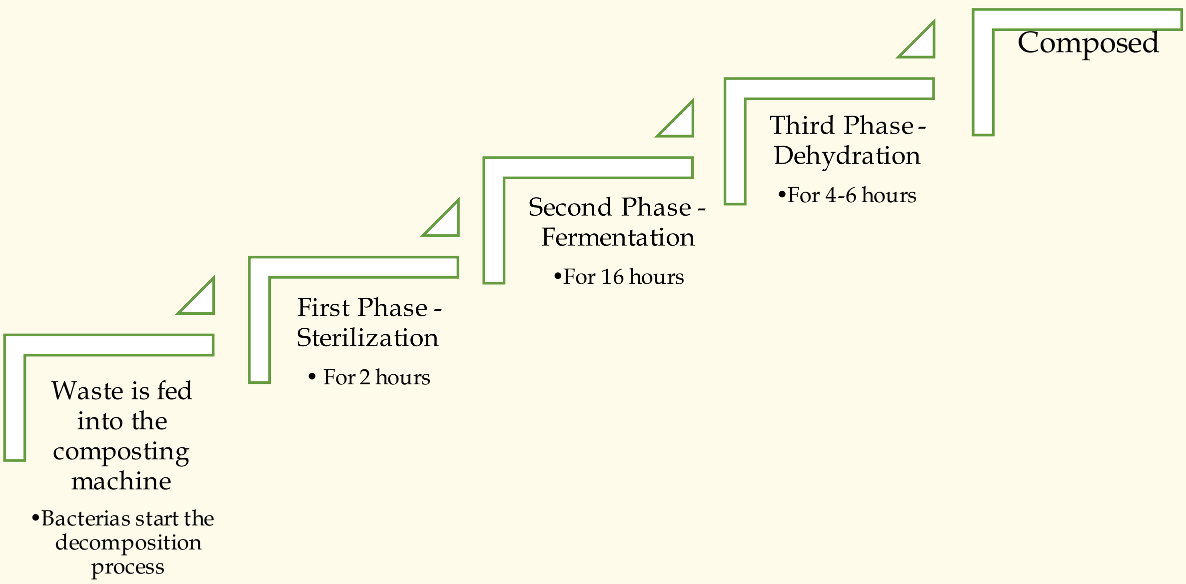
Figure 20 - Composting process (Greenaway, n.d.)

Composting is the biological process of transformation of organic matter, which can be of urban, domestic, industrial, agricultural or forestry origin. It can be considered as a recycling of organic waste. It is a natural process in which micro-organisms, such as fungi and bacteria, transform organic matter into humus, which is very rich in nutrients and an excellent fertilizer (eCycle Team, n.d.).

Humus is a stable organic matter present in various types of soil (clayey, sandy, among others). Scientist Ollech defined humus, in 1890, as "all substances that are formed in the decomposition and fermentation of organic matter of vegetable and animal origin, or through the action of certain chemical agents on this organic matter, in the form of amorphous organic compounds (which do not have a determined form), non-volatile, non-greasy, more or less dark". Humus is a stable substance, but it is not static but dynamic, since it consists of plant and animal wastes that are continuously being decomposed by micro-organisms. Humus makes soils fertile, provides nutrients for plants and regulates micro-organism populations. It is a source of essential nutrients for the healthy development of crops, such as carbon, nitrogen, phosphorus, calcium, iron, among others. It prevents toxic substances from passing through the soil to the plants, retains the humidity and maintains the soil temperature balanced (Legnaioli, n.d.).

The advantage of using hummus is that it is a natural fertiliser for plants, and at the same time, it reduces the amount of waste that would go to the landfill, avoiding the emission of greenhouse gases into the atmosphere (Legnaioli, n.d.).

The **composting machines** were developed to assist this process, which is labour-intensive and requires a lot of manpower. In the composting machines, the process is fully automatic. To start the process, the waste is fed into the composting machine. Bacteria start the decomposition process. In the first 2 hours a temperature of 90°C is used to kill harmful bacteria. Then the fermentation process takes place and the compost is formed, the temperature should be between 60 and 70°C for 16 hours. The last 4-6 hours are performed at 100°C, so that the compound is dehydrated and the product is obtained. The composting and soil distribution machine then allow 3 types of operations, sterilization, composition and provision of dehydration. In addition, the steam from the machine passes through a cooling system and becomes liquid (distilled water) and makes the product contain more than 80% organic matter.



Automatic irrigation system

Water is a fundamental element for plant development. And plants often obtain this water by being watered. **Irrigation** is a technique used to apply water to the soil in appropriate quantities. The use of appropriate irrigation techniques in conjunction with various operations such as soil fertility, pest and disease control, and correct fertilization, makes it possible to achieve the maximum level of crop yield. However, if irrigation techniques are not properly used, they can lead to excessive expenditure and waste of water resources (AJAP/Agri-Ciência, 2004).

There are several types of irrigation systems such as sprinkler irrigation, self-propelled irrigation, micro-sprinkler irrigation and drip irrigation.

Sprinkler irrigation "is characterized by the division of one or more water jets into a large number of small drops in the air, which fall on the ground as artificial rain" (BRUOF, 2017).

Figure 21 - Sprinkler irrigation (Elegant Polymers, n.d.)

Self-propelled irrigation "is a sprinkler system that consists of a single cannon or mini cannon and is mounted on a cart, which moves longitudinally along the area to be irrigated" (BRUOF, 2017).

Figure 22 - Self-propelled irrigation (Semear, 2020)

The micro-sprinkler system "uses emitters that release water droplets (in the form of rain) and provide smoother and more uniform precipitation than the sprinkler" (BRUOF, 2017).

Figure 23 - Micro-sprinkler system (Campezza, n.d.)

In the drip irrigation system "water loss through evaporation is reduced, providing better use of water, since it is deposited directly on the roots of plants forming small circles or wet strips" (BRUOF, 2017).

Figure 24 - Drip irrigation system (Dream Civil, n.d.)

Automatic irrigation systems have controllers, which are connected to a device that indicates when it rains or when the soil has sufficient moisture, inhibiting irrigation when it is not needed. The controllers have the particularity of having a safety battery for when the battery is insufficient. In places where water availability is not very accessible and constant, it is possible to use water from a cistern or well and irrigate through a pump (AJAP/Agri-Ciência, 2004).

Automatic irrigation has several benefits for farmers. These automatic irrigation systems allow farmers to save time and labour and better manage water resources, both in terms of the uniform distribution of water to crops, as well as reducing water waste (AJAP/Agri-Ciência, 2004).

Automatic irrigation systems are closely related to humidity sensors and/or weather stations. The data obtained by humidity sensors or weather stations allows us to understand the water needs and adjust the irrigation system. Farmers can access the water needs information from applications on both the mobile phone and the computer.

Figure 25 - Mobile Application (irritec, n.d.)

Water conservation methods

Water is a resource that is not infinite. On the contrary, it is increasingly scarce, and therefore it is of extreme importance to be used in a rational and efficient way.

One of the measures used for the re-use of water, approved by the Council of the European Union (2020), concerns the re-use of urban wastewater, properly treated for agricultural irrigation. However, urban wastewater needs to meet minimum requirements for re-use according to European Union and international standards. These standards must be followed in order to comply with food safety and public health standards. The reuse of treated wastewater, which may contain nutrients such as nitrogen, potassium, etc., can contribute to soil nutrient recovery during irrigation (Council of the European Union, 2020)

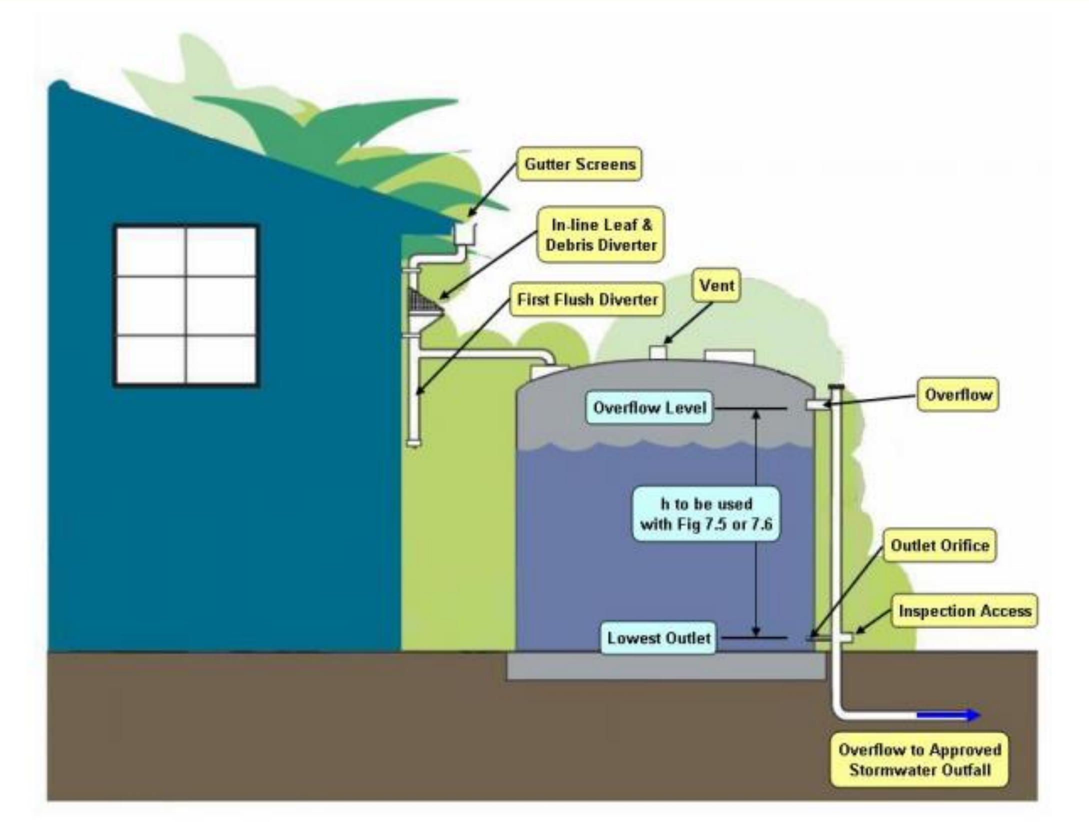


Figure 26 - Water retention tank (Euro plumbing, 2015)

Another method of water reuse is the use of water retention tanks. Water retention tanks are used to store rainwater and/or stormwater for future reuse. This type of system collects, transports and stores water in reservoirs. To guarantee the quality of the water, it is essential to have a cleaning device, namely with filters, in order to remove the residues and impurities. The water stored in the reservoirs is then used in irrigation systems. This system allows effective management of water resources, especially in times of drought. That is, during the rainy season the water is stored in the reservoirs and used in times of water shortage (Vianna, 2017).

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As has been stated before, technology plays an extremely important role in decreasing the pollution and waste of natural resources that come from agriculture. Therefore, it is essential to develop technologies that allow the generation and capture of energy and water.

Solar or photovoltaic panels

Solar or photovoltaic panels consist of cells that convert sunlight into electricity. The electricity produced in the solar panels generates a direct electrical current that has to be converted to the alternating current through an inverter. In this way, the electricity can be used after being produced and converted, and can be stored in batteries for later use or can be sold to the grid.

This energy, produced by photovoltaic panels, allows a great saving in expenses. For example, winemakers use the energy generated by solar panels for other activities, namely to press the grapes. Another example of using the energy generated by photovoltaic panels is for irrigation, particularly in summer, when there are more hours of sunlight per day and less rainfall. Since there are more hours of sunlight, the solar panels generate a large amount of electricity, which can be channelled into the operation of water pumps. This is a useful option for the extraction of water from wells, tanks and water tanks. In more remote locations, where there is no electricity distribution network or as a substitute for combustion-generating pollutants, off-grid systems can be used to supply pumps for well water removal and crop irrigation. The system consists of photovoltaic plates, cables, connectors, being necessary a specific inverter that converts direct current into alternating current (EDP Comercial, 2020) (ENON, 2019).

Pumped-storage hydroelectricity (PSH)

In addition to systems that use the sun as a source of energy production, some others use water as a source to generate electricity. This system uses pure water as a way to create a reversible hydroelectric hot water storage machine. Through this, the system is able to provide both heat, electricity and even cooling. Altitude is an important factor for this system to work, as it needs a large elevation of one between two different water reservoirs in relation to the sea level. Another essential element is a large amount of water. This is because when there is a surplus of energy produced. This surplus is used to pump the water from the highest reservoir, which is poured into the turbines and the energy is generated. Water has a large specific heat, the capacity it has to accumulate heat without evaporating, is an excellent means of a heat reserve. Hydroelectric energy is used to heat the water to 90º, and this thermal energy is stored and used through heat exchange systems installed in underground reservoirs. When there is a heat demand, through a district heating system this heat reaches the consumers. This system also uses a cooling system. On hot days, the hot water drives a chiller, which provides cooling energy, which can also be distributed to consumers through the pipe. This system can result in a capacity of 80% efficiency in the storage of heat and electricity (Reis, 2019).

Livestock farming tools

In the previous parts, the technical equipment for agriculture was presented. As livestock farming is closely related to agriculture, examples of technologies applied to this sector will be presented, namely in the area of packing and mechanical weighing of eggs and robotic milking system.

Machine packing and weighing eggs

Figure 27 - Machine packing and weighing eggs (Ovobel, n.d.)

The eggs can be collected by an automated egg collection system. When collecting the eggs, a pre-classification is carried out, where cracked and dirty eggs are rejected. The remaining eggs are inspected again, rejecting those that do not provide guarantees for the final consumer. The eggs are analysed by a process known as egg-copy, which consists of the incidence of a light beam on the eggs in a low-light environment, where it is possible to observe the eggs with cracks, dirt, deformations in the shell and yolk. These eggs are normally discarded. The process of egg copying takes place twice.

After the first egg-copy, the eggs are washed, dried, brushed and disinfected automatically in a UV bath. After cleaning, the eggs undergo the second egg-copy. Then they pass through the crack detector (it is an automatic crack detector that usually separates eggs that have cracks or fissures that cannot be seen with the naked eye).

The next process is the weighted grading of the eggs. This is carried out by an automatic scale integrated into a sorting machine and consists of weighing and depositing according to kilograms automatically on a tray. After grading and nesting the eggs in the trays, these proceed to the end of the machine, where they are collected and packed.

The packaging of the eggs must contain a code identifying the country of origin, the production method, the agricultural region where it is produced and the respective poultry house. The quality parameters – chemical composition and microbiological content – must be checked regularly in the laboratory. This process guarantees the final consumer the acquisition of a product with excellent characteristics in terms of health, nutritional value and genuineness (Akeida, 2017).

Automatized milking system

Robotic milking systems are increasingly used in dairy plants, thus optimising production and time management. However, this system presents a high capital investment.

Robotic milking works in the following way: after the electronic identification of the animal, the door to the milking area is opened automatically and the system checks if the animal has criteria to be milked. If a certain set of criteria are met, the milking process starts. If not, the animal is guided to the exit through the automatic door. During milking, the robotic arm location system identifies the teats of the animal and their positioning. Before milk extraction, the animal's teats are washed with water jets

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and dried with air or mechanically cleaned with brush rollers. The mechanical arm connects them to the beginning of the milking.

Figure 28 - Robotic milking system (Agro Planning, 2019)

Removal of the mechanical teat arm takes place automatically when the milk flow decreases to predetermined levels. After each milking, a disinfectant spray is applied to each teat. There are two approaches to locating the teats: the first determines the approximate teat position, the second determines the precise position of each teat. Cross-teat animals cannot be milked with this method, since the infrared bone marrow of the equipment is not able to detect cross-teats. However, there is more modern equipment with built-in 3D vision cameras that allow the detection of irregular teats (Silvi et al, 2018).

As part of the next STEM concepts, we tackle two different subjects that are inter-connected: engineering and mathematics. As analysed at the beginning of chapter 3, these are particularly helpful in order to come up with solutions to several agricultural problems.

ENGINEERING AND MATHEMATICS

Along with Science and Technology, Engineering and Mathematics have a prominent role in STEM applications in the agriculture sector. In this section we elaborate on the role of those two fields, with particular reference to environmental engineering and the concept of eco-friendly communities.

Environmental Engineering

As it has been briefly touched upon at the beginning of chapter 3, environmental engineering is a field of engineering focusing on the protection of communities and the environments from the effects of adverse environmental effects, such as pollution, with actions such as the improvement of recycling, waste disposal, public health, and water and air pollution control. Otti, Nwafor, and Dan (2018) define environmental engineering as the field concerned with the protection and prevention of the environment, including the development of solutions for addressing environmental problems (Otti et al., 2018). Therefore, environmental engineering aims to improve the environmental quality, which can be achieved by a series of actions aiming to a Green Economy (see below for more information).

The origins of this field are rooted in the mid-19th century, when, Joseph Bazalgette, the first environmental engineer, oversaw the construction of the first large-scale municipal sanitary sewer system in London. This was prompted by a series of cholera epidemics, as well as a persistent unbearable stench, that were attributed to the discharge of raw sewage into the Thames River, which was also the main source of drinking water for the city. In recent years, there has been a growing development in the environmental engineering field, as documented by policies and emphasis given in the creation of eco-friendly communities. The impact of environmental engineering on our society has never been clearer due to our recent economic growth and the associated environmental problems.

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Eco-friendly communities

During the last decades, there has been an increased effort towards a green economy, in response to humans' actions which contribute to climate change and biodiversity loss (Global Footprint Network, 2010). As part of this effort, several challenges have to be confronted, such as the ecological footprint resulted from countries which have already attained high levels of human development at the expense of their natural resources (Global Footprint Network, 2010; UNEP, 2010; UNDP, 2009).

Part of this effort includes planning and developing sustainable, accessible, and eco-friendly communities. Eco-friendly communities can be considered the communities which embrace goals and initiatives linked to a Green Economy. Cities could also become eco-friendly communities, or often called eco-cities, as they play a leadership role in catalysing global action to address climate change (Eryildiz & Xhexhı, 2012). The **"eco-city"** term can be traced back to the mid-1970s when it was first coined in the context of the rising environmental movement. In recent years, more efforts are evident aiming towards the creation and sustainability of such eco-communities, which comply with the Green Economy.

> A Green Economy can be defined as
> "an economy that
> results in improved human well-being and
> reduced in inequalities over the long term,
> while not exposing future
> generations to significant environmental risks
> and ecological scarcities"
>
> (UNEP, 2010, p. 3)

Figure 29 - Definition of Green Economy (UNEP, 2010)

Actions that eco-friendly communities follow and which can lead to a Green Economy, include among others, investments in economic sectors (e.g., renewable energy, low-carbon transport, energy efficient buildings or so-called eco-friendly buildings, clean technologies, improved waste management, improved freshwater, provision, sustainable agriculture and forest management, and sustainable fisheries) that build on and enhance the earth's natural capital or reduce ecological shortages and environmental risks.

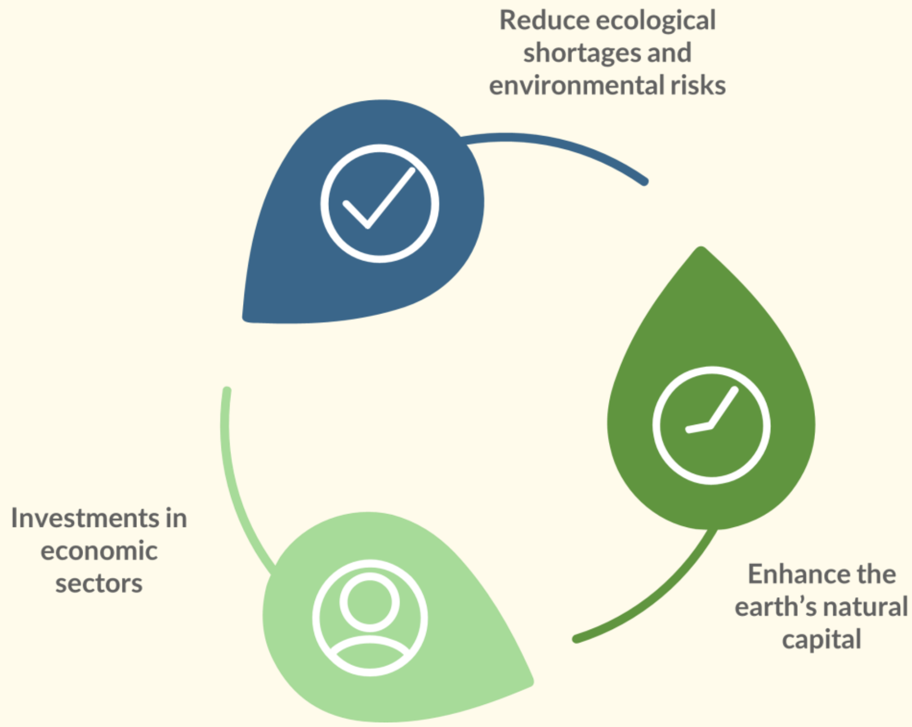

Figure 30 - Actions that eco-friendly communities follow, and which can lead to a Green Economy

Implications of those actions can be found in the creation of "greener" jobs, lower energy and resource-intensive production, lower waste of natural resources and decrease of earth pollution, and significantly lower greenhouse gas emissions, as compared to more conventional ways of resources' exploitation (e.g., carbon). Overall, the critical aspects of a Green Economy establishment (GIZ and ICLEI, 2012) deal with:

(a) the development, promotion and deployment of green technologies and innovations;

(b) the provision of strategies and tools to explore, identify and apply green business and governance models in practice;

(c) the identification and diffusion of green business opportunities.

As proposed by Addanki and Venkataraman (2017), in order to safeguard the development of sustainable cities that comply with the above-mentioned points, there is a need to carry out multidisciplinary research in the STEM (Science, Technology, Engineering and Mathematics) fields, for addressing those challenges and for developing technological solutions. In addition, stakeholders and entities from the business community could be motivated to create investment for start-ups, focusing on different nuances of sustainable cities (Addanki & Venkataraman, 2017) and to collaborate with the government towards achieving the Green Economy goals.

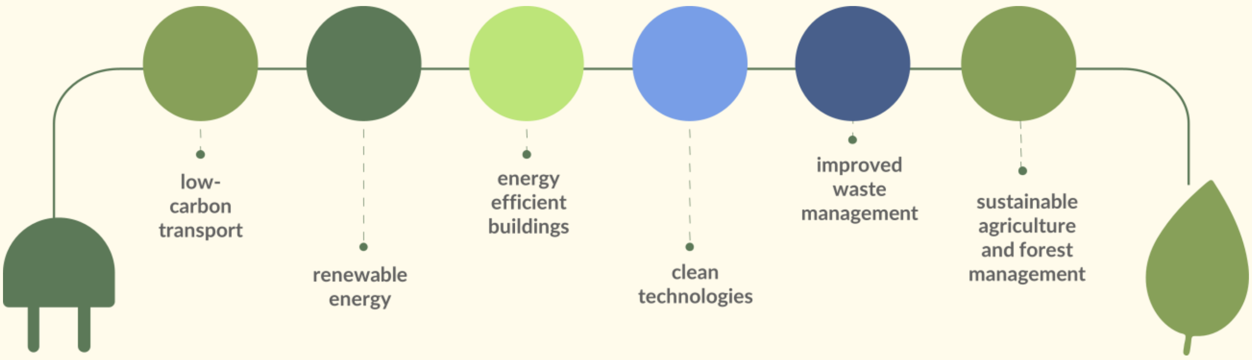

Figure 31 - Investments in economic sectors which can lead to a Green Economy

3.3 "Design Thinking Process" methodology

A methodology that will be used in the course of "Green STEAM Incubator is" the **"Design Thinking Process"**. This encompasses a widespread approach to solve socially ambiguous design problems (Lindberg, Gumienny, Jobst, & Meinel, 2010). Cross, Dorst and Roozenburg (1992) provide a definition of the process, referring to a study of the cognitive processes that are manifested in design action, as well as something inherent within human cognition (Cross, 2011). According to other scholars in the field (Dunne & Martin, 2006), design thinking is the way in which the designers think and apply their mental processes to design objects, services or systems, as distinct from the end result of elegant and useful products. A Design Thinking methodology is applied in multidisciplinary work within creativity-promoting environments. It is comprised by five key phases: **empathize, define, ideate, prototype and test** (Plattner, Meinel, & Leifer, 2010). The method is based on the work of designers, which is understood as a combination of understanding, observation, brainstorming, refinement, execution, and learning.

In the literature, different designs thinking models are reported (see: Brown, 2006, 2019; Dunn & Martin, 2006; Eric, 2007). For instance, the design thinking model proposed by Brown (2006, 2019) details how design thinking happens by means of three overlapping spaces namely: Inspiration, Ideation, and Implementation. There are several sub activities in each space, which are described as a system of spaces rather than a pre-defined series of orderly steps. Another model of design thinking process is presented by Dunn and Martin (2006) and consists of four activities namely: Abduction, Deduction, Test, and Induction. The Abduction activity focuses on generating ideas and during the Deduction activity, those ideas are being analysed to predict likely consequences. All predictions are then tested, and valid outcomes are generalized during the Induction stage. Also, Eris (2007) presented a model named Divergent-Convergent Inquiry based Design Thinking Model (DCIDT) that describes design thinking as divergent and convergent inquiry associated with two fundamental modalities: divergent and convergent questioning.

Application of DTP in Green STEAM Incubator

In the Green STEAM Incubator project, and as part of the microcontrollers' and 3D Modelling modules, participants will be enabled to come up with their own ideas of environmental projects and eco-friendly solutions that could be applied in permaculture for instance, through the method of Design Thinking, an approach designed to solve (environmental or other) problems and develop ideas, by designing solutions that are convincing form the user's point of view.

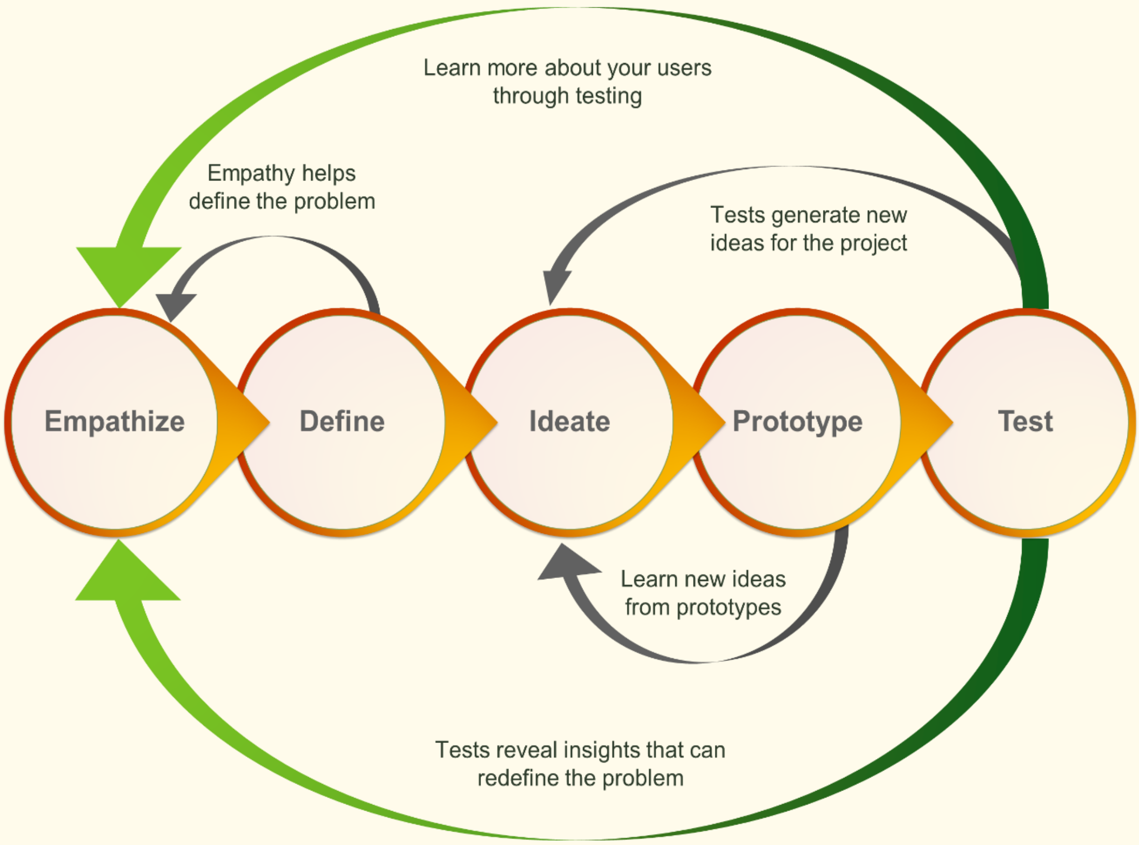

Figure 32 - The non-linear design thinking process

The design thinking of Brown (2006, 2019) will be endorsed, during which, the participants will be invited to experience three phases: Inspiration, Ideation, and Implementation. Following this approach, the users will be engaged in the design process of their solutions (see Figure 32), by identifying first their needs through brainstorming and understanding the problem(s) to solve, generating ideas and mind mapping or storyboarding, then, by prototyping and planning their solution, and finally by testing their prototypes and proceed to improvements in new prototypes through an iteration process. The aim of these activities will be to design solutions for some of the problems which have been identified and discussed with the participants of the project's training activities.

The stages of DTP through practical examples

The stages of the methodology are further explicated below (see table 1), with examples of practical applications.

Table 1**.** Stages of the methodology along with indicative practical applications

Stages	Short description of the stage	Practical application example
Empathize	Think about your user, observe, and interact with your user(s). Understand their experience, ask what their needs and interests are related to your idea. What is important to them? Further research might be necessary to understand the point of view of the user.	At this stage it is important to understand our target group (i.e., agroentrepreneurs), getting informed about who they are, what kind of activities they currently undertake at their farms, their future plans, but also possible barriers and constraints that they confront in materializing certain tasks. We approach and interview the agroentrepreneurs, discuss with them the above-mentioned points. Interview data are recorded in order to be further examined and used for the creation of action plans.
Define	Synthesize your findings from the empathize step to highlight user needs and other insights.	Through this interaction and looking into our interview data, we try to identify problems, needs, and missing gaps. Also, to understand the reasons for those needs, e.g., Why exactly is this a problem for the target audience? We limit ourselves into a single problem. For the purposes of this example, let us assume that there is a need for the

		agroentrepreneur in having a machine for composting.
Ideate	Identify the best solution from a range of possibilities. Generate ideas through brainstorming, mind mapping, storyboarding and other techniques.	We brainstorm and research about how to create a composting machine with eco-friendly materials. Restrictions are being considered (e.g. cost) while brainstorming ideas. In co-design approaches, this stage may actively involve the end-users/ target audience.
Prototype	In prototype, plan your approach, think about materials you need and keep your user in mind as you get organized for building your first prototype. Make some initial sketches with labels for parts and measurements where needed.	The ideas noted from the previous stage are being reviewed and grouped into clusters. We limit our ideas into a single solution that we will further prototype. We consider the materials that we need, we sketch the prototype, and further proceed with designing a first version of the composting machine. While doing so, it is vital to write down the steps followed for building the prototype, as well as, the problems which may have occurred. This piece of information is critical for making further improvements and refinements.
Test	Think about how you will test your prototype and make improvements in new prototypes.	We test the machine with end-users and listen carefully to what they think about its functionality. We select feedback comments and if necessary, repeat the whole process by making improvements and refinements to the product.

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The importance of DTP

The Design Thinking methodology endorses a constructivist approach of learning, advantages of which have been well-determined through theoretical findings in pedagogy. Design Thinking, as an inherently team-based learning process, offers opportunities to individuals to engage in practice-oriented and holistic modes of constructivist learning in projects, and to foster their 21st century skills (Scheer, Noweski, & Meinel, 2012) and the so-called, soft skills (Lee & Benza, 2015). Also, the design thinking methodology comprises a human-centred problem-solving approach which cultivates creativity and innovation (Luka, 2014). It is also argued that innovation skills, including technical skills (e.g., discipline specific expertise), personal qualities (e.g., creativity and open-mindedness) (see also: Rauth, Köppen, Jobst, & Meinel, 2010), and social and behavioural skills (e.g., communication and collaboration) can be fostered through the enactment of the design thinking methodology (Lee & Benza, 2015). In fact, the Design Thinking approach has been chosen as a pedagogical method to teach innovation skills in entrepreneurship and business courses (Lee & Benza, 2015; Linton & Klinton, 2019). The importance of facilitating the development of innovation skills has been recognised by both employers and educators in the domain. In this view, the Design Thinking approach can be adopted as an underlying pedagogical method for promoting the facilitation of the aforementioned skills.

Green STEAM Incubator

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CHAPTER 4

DEVELOPING COLLABORATIONS BETWEEN YOUTH ORGANIZATIONS AND AGRO-BUSINESSES

The “Green STEAM Incubator” Manual is being introduced through a framework designed both to bring young people closer to farms and agro-entrepreneurship, as well as to inspire them to develop an understanding about the way those operate. This will be accomplished in the context of collaborative activities between youth organizations, youth workers and agricultural stakeholders, which will introduce learners to the agribusiness life. Furthermore, they will be introduced to concepts such as environmental education, permaculture and the latest technological innovations in the field of agriculture. The activities, require on-site facilitators that will indicate all the practical arrangements. Additionally, they have been designed as such, so that they are feasible in each partner country and on various types of farms.

The methodology followed for designing these activities is explained here, in an effort to support any interested readers in creating their own workshop activities. As mentioned beforehand, the partners have taken interviews from the agro-entrepreneurships and farms. Afterwards, they recorded the interviewees’ operational methodologies, their needs and current ideas for educational activities targeting youth.

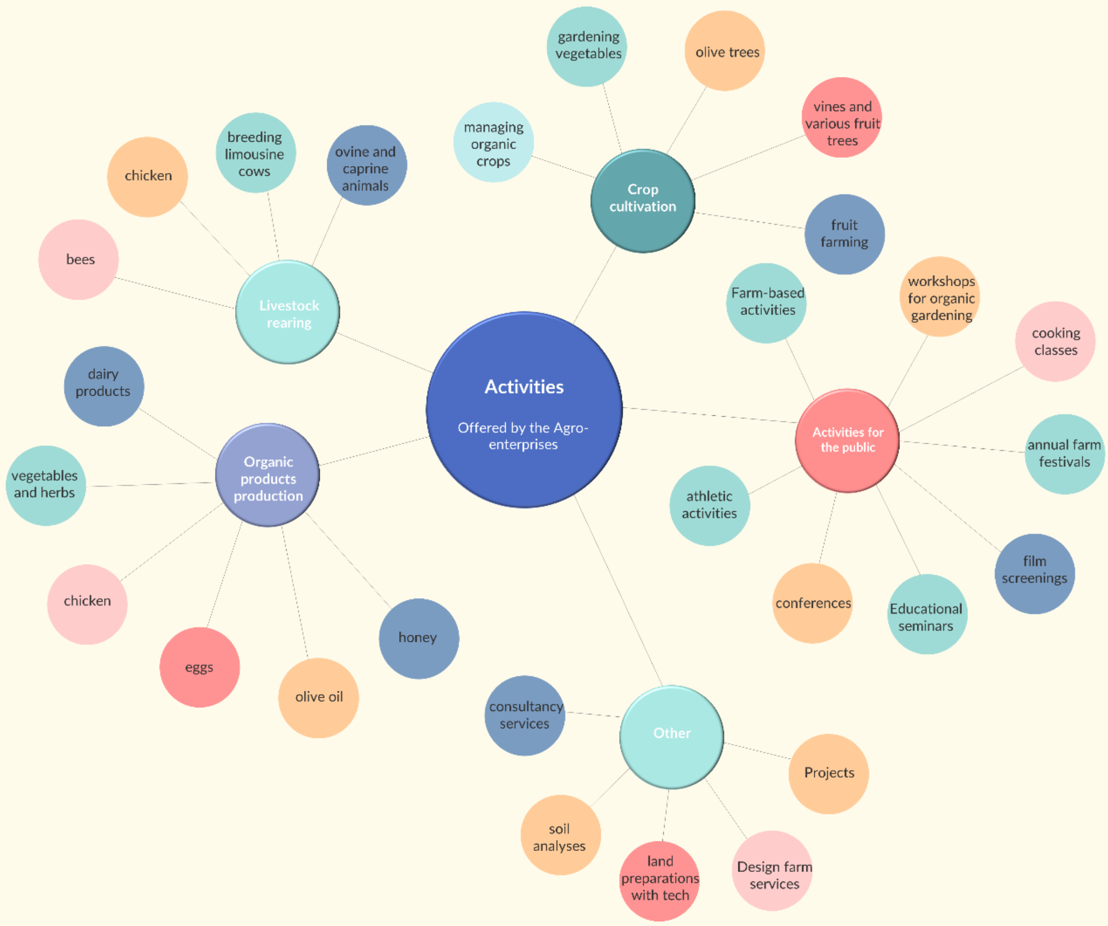

Figure 33 - Different types of operational methodologies and activities offered by the agro-enterprises

These discussions operated as a starting point for development of Action Plans for the collaborative frameworks between youth organizations and agricultural organizations. The Action Plans provided useful and helpful information about the STEM technological equipment of the agro-enterprises, as they analyzed in depth how STEM theories can be related to agriculture and applied on the ground.

Activity name	Short description of activity	Type of activity	Objectives	Target group and age-range	Required resources for implementation	Necessary tech equipment (including STEAM)

Existing material (ex. preparatory material)	Potential barriers	Steps towards implementation	Proposing organization (farm/ agro-entrepreneurial stakeholder)	Contact details	Means of communicating the activity

Figure 34 - Template for Action Plans

All the above took into consideration the reinforcement of participative learning experience for youth in conjunction with an exposition of agro-entrepreneurial technological innovations and eco-friendly methodologies.

Find the list of activities on the table below. The table distinguishes the activities between the ones that are foreseen to be implemented indoors (ex. at the offices of a youth organization), outdoors (at the agro-enterprise) or in both settings. Nonetheless, each facilitator can adapt the activities depending on their participants, available resources and educational objectives.

Hope you enjoy the activities!

	Name of the Activity	Indoor	Outdoor	Indoor and Outdoor
1	Learning about conventional and organic farming	√		
2	Adoption of STEM technologies	√		
3	Data processing fun	√		
4	Building a farm	√		
5	Perma-venger hunt		√	
6	Sustainable Cooking Class			√
7	Creating your own community garden			√
8	A self-sustained agricultural infrastructure			√
9	Operating a Humidity Sensor			√
10	Operating a weather station			√
11	Measuring the PH of soil			√
12	Composting			√

Activity 1 - Learning about conventional and organic farming

- **STEM field:** Science
- **Indicative calendar:** Any time of the year
- **Activity duration:** 120 minutes
- **Type of activity:** Indoor workshop
- **Educational objectives:**

  The objective of this activity is for participants to learn about the definitions of conventional and organic farming and practice their argumentation skills.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:

  - critically study available resources about conventional and organic farming
  - define conventional and organic farming
  - synthesize arguments in favour and/or against conventional and organic farming
  - synthesize the outcomes of their inquiry in a brief report/ poster
  - engage in a debate.

- **Required material and resources:** Computer, projector, power point presentation (with the scenario and informative text on argumentation), relevant sources to be studied by the participants, A3 cardboards, colour pencils and markers, scissors

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Training sessions

1. Preparation (10 minutes)

Before the workshop, the facilitator prepares some questions to introduce the participants gradually to the subject of the activity. Indicative questions are given below.

- Have you ever heard of conventional and organic farming?
- If yes, share your experiences and knowledge.
- If not, what do you think those two terms refer to?

2. Introduction (20 minutes)

For exercise with the participants

Subject: Scenario with two farmers

Instructions: The participants are given a scenario with two farmers, an organic and a conventional farmer, who aim to sell their products and in doing so, they must persuade their customers based on a series of arguments. The following text is provided to the participants. The names are subject to adaptation.

“Mr. Giannis cultivates and sells biological vegetables in the market of his region. Mr. Andreas cultivates vegetable in a conventional way and sells them in the same market. Each one of the two farmers tried to persuade the market costumers to buy his own products with a series of arguments. Can you think about possible arguments that each farmer might be using?”

Figure 1. Scenario with two farmers. Photo on the left retrieved from: https://www.dreamstime.com/stock-illustration-cheerful-vegetable-seller-counter-carrot-his-hands-image54681381. Photo on the right retrieved from: https://www.dreamstime.com/illustration/farmer-shouting.html

A plenary discussion takes place, during which the participants express their opinion on possible arguments that the two farmers use in order to persuade their customers.

3. **Main session (30 minutes)**

Information for the facilitator

Subject: Argumentation

The facilitator makes a short presentation on argumentation and the essential components of a valid argument. This is supportive to the task that follows, during which the participants will be engaged in a short debate. Depending on the group of learners at the workshop, the facilitator can spend more or less time on this.

Argumentation

Argumentation is defined as the process of presenting substantiated views (claims) (Kuhn & Udell, 2003) with the aim of supporting, criticizing and evaluating opposing views (Kuhn, 1992; Naylor, Keogh & Downing, 2007).

The argument serves as the tool to advance the argumentation process.

Argumentation

Social and collaborative process used to "solve problems and promote knowledge" (Duschl & Osborne, 2002, p.41)

Attempting to justify or refute a particular view (van Eemeren et al., 2002, p.38)

Process of proposing, supporting, evaluating, and refining ideas in an effort to understand a complex and unspecified problem (Clark & Sampson, 2008).

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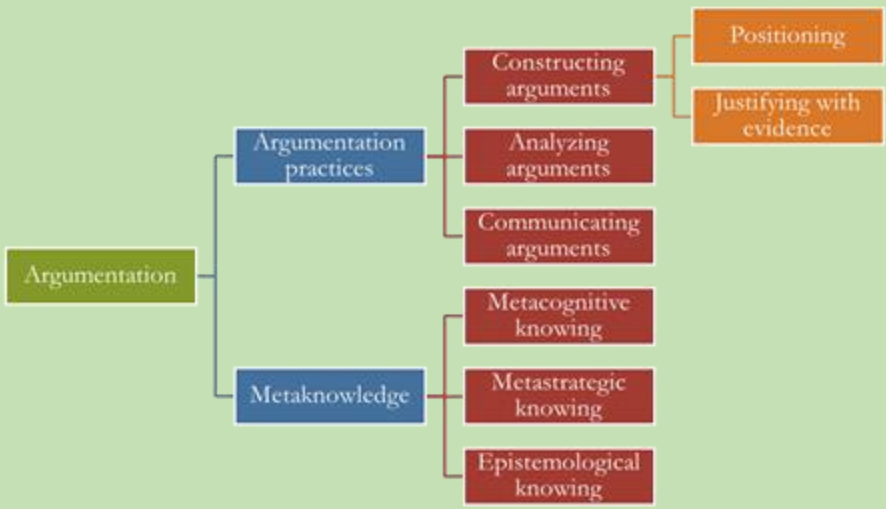
Argument

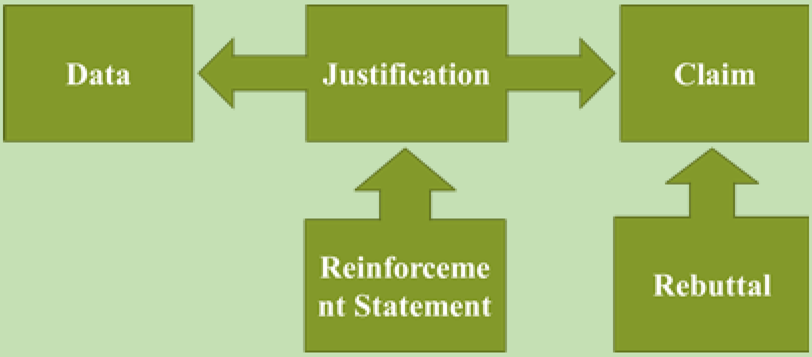
- An argument must be clearly stated using claims, positioning, or conclusion.
- It must be supported with data/ evidence.

(Jimenez–Aleixandre et al. 2000)

Argumentation competence



Toulmin's model



See: Brockriede & Ehninger (1960)

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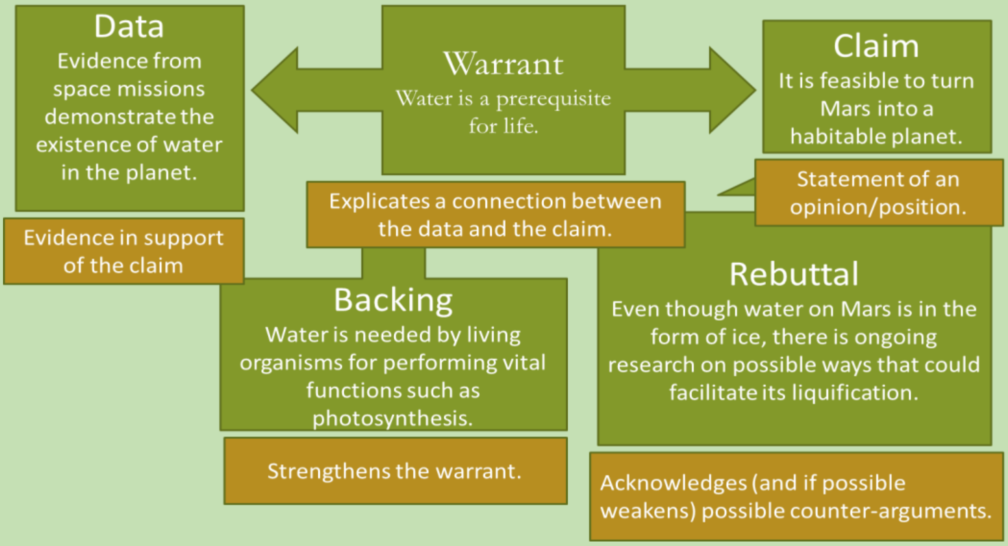
Analysis of an example

Is it possible to inhabit the planet Mars?

An example of Toulmin's Model:
it is feasible to turn Mars into a habitable planet?



4. Exercises (40 minutes)

Participants form two groups, in order to engage in a debate, during which they will be invited to present their arguments. The participants are first asked to search and study in their group relevant resources, for developing their own arguments on the pros and cons of the two farming methods. Below we provide an indicative list of sources.

Information for the facilitator

Subject: Text sources for the debate

Text sources:

- For both groups
https://behindtheplow.com/conventional-vs-organic-farming-which-should-you-practice/

- Organic farming supporting position:
https://rodaleinstitute.org/why-organic/organic-basics/organic-vs-conventional/

- Conventional farming supporting position:
https://greengarageblog.org/7-pros-and-cons-of-conventional-farming

For exercise with the participants

Subject: Debate

Instructions: Students form two groups. Each group is provided with a A3 cardboard, color pencils and markers, scissors, which can be used for the creation of a poster, presenting in brief their position and arguments. As soon as the posters are finalized by both groups, the participants are invited to a plenary debate, in which they are asked to present their arguments. The facilitator monitors the debate and the exchange of questions between the two groups.

Debate

Study the resources which are given to you.

Construct your arguments to support your position.

Prepare a poster with your arguments.

Let us start the debate!

5. Debriefing session (10 minutes)

The facilitator leads a debriefing session, during which the main arguments from the two sides are summarized.

6. References for activity 1

Brockriede, W., & Ehninger, D. (1960). Toulmin on argument: An interpretation and application. *Quarterly journal of speech*, *46*(1), 44-53.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science education*, *84*(3), 287-312.

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education.

Jiménez-Aleixandre, M. P., Bugallo Rodríguez, A., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science education*, *84*(6), 757-792.

Kuhn, D. (1992). Thinking as argument. *Harvard Educational Review*, *62*(2), 155-179. https://doi.org/10.17763/haer.62.2.9r424r0113t670l1

Kuhn, D., & Udell, W. (2003). The development of argument skills. *Child development*, *74*(5), 1245-1260.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in science education*, *37*(1), 17-39.

Sampson, V., & Clark, D. B. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science education*, *92*(3), 447-472.

Van Eemeren, F. H., Grootendorst, R., Jacobs, C. S., & Jackson, S. A. (2002). *Reconstructing argumentative discourse*. The University of Alabama Press.

Activity 2 - Adoption of STEM technologies

- **STEM field:** Technology
- **Indicative calendar:** Any time of the year
- **Activity duration:** 100 – 120 minutes
- **Type of activity:** Indoor workshop
- **Educational objectives:**

  The objectives of this activity are for participants to understand the value of adopting STEM technologies in farming and agriculture, and in particular the impact of new technologies in the future of farming.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:
  - participate in a workshop, during which collaborative activities (e.g., brainstorming, group discussion, mini project, group presentations) will be offered, aiming to highlight the added value of STEM technologies in the field of agriculture.
  - will enhance their collaboration and social skills,
  - will cultivate their presentation and their inquiry skills.

- **Required material and resources:** Computer, projector, power point presentation, A3 cardboards, colour pencils and markers, handouts, the participants are required to bring their own laptops.

Training sessions

1. Preparation

The facilitator will present a YouTube video to the participants. As the video is in English, the facilitator should safeguard that either the participants understand English or prepare and upload subtitles in the native language.

2. Introduction (15 minutes)

Information for the facilitator

Subject: TED Talk Video

TED Talk Video:
https://www.ted.com/talks/sara_menker_a_global_food_crisis_may_be_less_than_a_decade_away?referrer=playlist-what_s_the_future_of_food

The facilitator shows to the participants the TED Talk (or parts of it) A Global Food Crisis May be Less Than a Decade Away by Sara Menker. S/he pauses the talk at 2:29 and discusses Sara's statement, "*We could have a tipping point in global food and agriculture if surging demand surpasses the agricultural system's structural capacity to produce food.*" The facilitator opens a discussion on the concepts of supply and demand as well as a "capacity" to produce food.

As demand (population) rises, what limits our capacity to produce food? (arable land, water, soil nutrients, etc.).

For exercise with the participants

Subject: Capacity to produce food

Instructions: The participants discuss on the following questions in their groups.

- What limits our capacity to produce food?
- What are some things that can increase our capacity to produce food?

➢ One way of expanding our capacity to produce food is through the use of new technologies, which will be the main focus topic of this workshop.

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3. Main session

- Step 1 (15 minutes)

The facilitator poses the questions below and then, allows the participants to brainstorm their own ideas.

"What are some things that can increase our capacity to produce food?"

The facilitator points out that, one way of expanding our capacity to produce food is through the use of new technologies, which will be the main focus topic of this workshop.

Information for the facilitator

Subject: Use of technology in agriculture

Life on the farm 100 years ago looked vastly different compared to today and it will continue to change to meet the needs of the world. Cutting-edge technology and innovations are being used in agriculture. These new technologies are being developed with a purpose to overcome the challenges we face in providing food, fuel, and fiber for a growing population. The use of technology can be found in nearly every aspect of our daily lives and has revolutionized farming with more innovation on the horizon! Some technologies are emerging while others have been adopted globally.

Figure 1. Retrieved from: https://view.ceros.com/conference-board-of-canada/artificial-intelligence-anda-thea-global-trade-environment-1

- Step 2 (10 minutes)

Information for the facilitator

Subject: Video link on technologies and innovations being developed around the world

The facilitator shows to the participants the video on technologies and innovations being developed around the world. The participants are thus being introduced to several innovations that can be used in agriculture. As they watch, the participants are prompted in advance to consider the challenge(s) that each innovation could help to overcome. Video link:

Video:
https://www.youtube.com/watch?v=qexChWNFY5E&feature=youtu.be

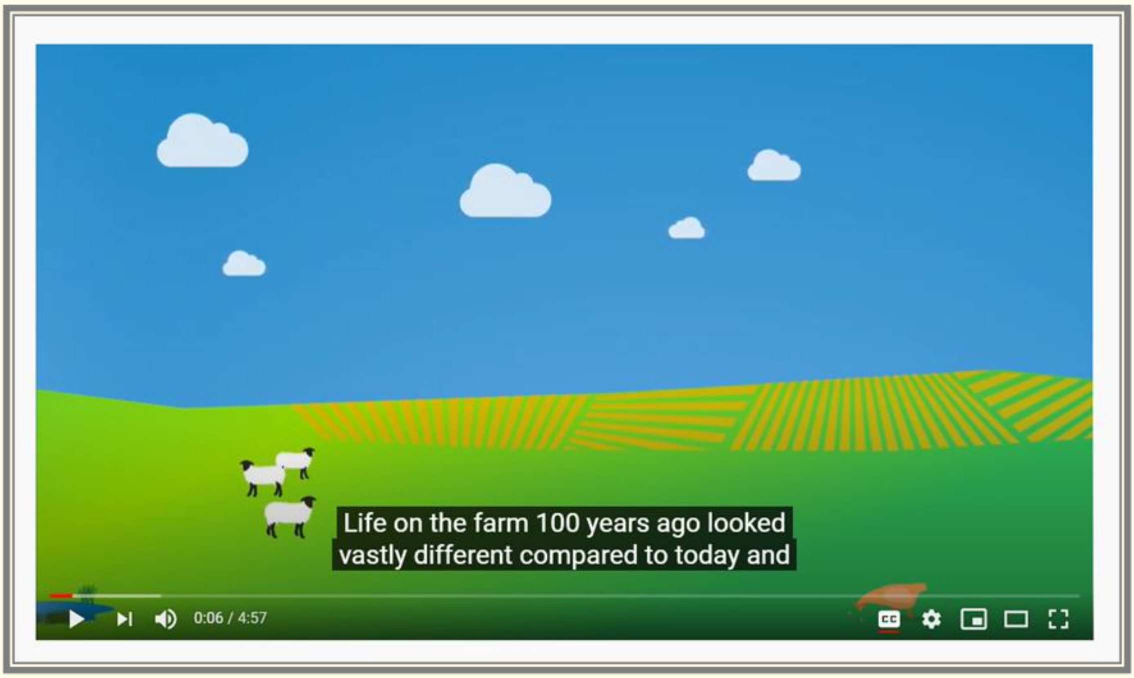

Figure 2. Screen shot from the video on *Technology and innovation in agriculture*.

- Step 3 (10 minutes)

After the video, a group discussion follows on the following questions and then a plenary discussion for exchange of views.

- Which innovation do you think could be most impactful and why?
- What are some pros and cons of using these technologies?

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4. Exercises (30 minutes each)

For exercise with the participants

Subject: Group activity

Instructions: Each group receives one copy of a handout (see Appendix). The facilitator provides time for the participants to perform research and create a digital presentation on their laptops about a specific technology to share with the rest of the people. The facilitator makes a random distribution of the topics/ technologies to be further investigated from the participants, an indicative list of which is given below: autonomous robots, agriculture sensors, aerial crop imaging, agriculture data systems, global positioning system (GPS) guidance systems, GPS yield and soil monitors/maps, livestock activity monitors etc. The participants are given with a list of resources that they can use (see: Sciforce, 2020; United States Department of Agriculture, 2016), but they are free to also use their own resources. The participants should use the four sections found on their handout to outline their research and presentation.

Technologies available for farmers:

Sensors: soil, water, light, humidity, temperature management

Software: specialized software solutions that target specific farm types or use case agnostic IoT platforms

Connectivity: cellular, LoRa, etc.

Location: GPS, Satellite, etc.

Robotics: Autonomous tractors, processing facilities, etc.

Data analytics: standalone analytics solutions, data pipelines for downstream solutions, etc. (Sciforce, 2020).

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Describe it. Describe the technology, how it is used, where it is used, etc. If possible, include details such as how much it costs and if it is currently being used in agriculture today.

What are the benefits? What obstacle(s) does this innovation overcome?

What are the limitations? Each form of technology has limitations. What are they? Is it the expense of the equipment, accuracy of its use, etc.?

See it in Action! Have the participants find images or a demonstration video of the technology in action.

Figure 3. Smart farming. Image retrieved from https://www.iotforall.com/smart-farming-future-of-agriculture/

For exercise with the participants

Subject: Presentations and discussion on the plenary

Instructions: As each team presents its own project, the rest of the participants are prompted to think about what changes in society, environment or economy would have to be made for the innovation to be adopted globally.

5. Debriefing session (5-10 minutes)

The facilitator leads a plenary discussion, during which the participants are prompted to reflect on the new concepts that they have learned and to ask any further questions.

"Smart Farming is an emerging concept that refers to managing farms using modern ICT to increase the quantity and quality of products while optimizing the human labour required." (Sciforce, 2020).

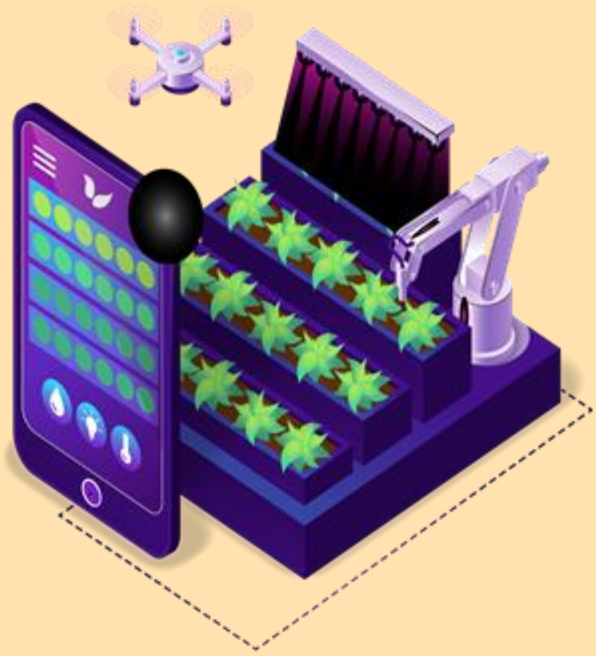

Figure 4. Smart farming. Image retrieved from: https://ragnoelectronics.com/smart-agriculture/

6. References for activity 2

National Agricultural Literacy Curriculum Matrix (2013). High-Tech Farming. Retrieved from: https://learnaboutag.org/teacher/matrix/lessonplan.cfm?lpid=691

Sciforce (June 22, 2020). Smart Farming: The Future of Agriculture. Retrieved from: https://www.iotforall.com/smart-farming-future-of-agriculture/

United States Department of Agriculture (2016). Precision Agriculture Technologies and Factors Affecting Their Adoption. Retrieved from: https://www.ers.usda.gov/amber-waves/2016/december/precision-agriculture-technologies-and-factors-affecting-their-adoption/

Autonomous Robots

Can we decrease the demand for farm laborers by using robotic machines to harvest fruits and vegetables rather than picking them manually?

Describe it…	What are the benefits?
What are the limitations?	**See it in Action!**

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Activity 3 - Data processing fun

- **STEM field:** Mathematics
- **Indicative calendar:** Any time of the year
- **Activity duration:** 45 minutes
- **Type of activity:** Indoor workshop
- **Educational objectives:**

  The objective of this activity is for participants to understand the importance of mathematics in agriculture.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:

  - calculate the size of the filed
  - analyze how much fertilizer and water is needed for the field
  - determinate optimal amount of seeds needed to be plant on the field

- **Required material and resources:** Printed scenarios, paper, pen and if needed a calculator.

Training sessions

1. **Preparation (5 min)**

Information for the facilitator

Subject: Examples of statements for preparation

Instructions: Before the workshop, the facilitator prepares a list of questions which can only be answered with yes or no. These questions should begin with "Have you ever...?" or "Stand up if...".

The facilitator reads out the questions or statements one by one. For each statement, the participants stand up if they could answer the statement with yes.

1. Stand up if you think mathematics is boring.
2. Have you ever applied any mathematics in real life?
3. Stand up if you think agriculture needs mathematics.
4. Have you ever killed a house plant because you put too much or too little water to it?
5. Stand up if you know how to convert units very fast.
6. Have you ever thought on mathematics lesson "why do I need to know this?"

2. Introduction (5 minutes)

Information for the facilitator

Subject: Examples of using mathematics in agriculture

Instructions: The facilitator gives a small introduction about the importance of math in the agriculture.

Mathematics is the science that concludes with the logic of shape, quantity and arrangement and there are a countless number of things that we could do with mathematics. Some of the principle uses are:

- measuring of soil fertility
- estimating crop yield
- calculating costs and profits
- conversion of units and measurement of area
- grading and describing seeds

It is important to know that mathematics is everywhere and as agriculture feeds the world it is doing it through numbers and calculations.

3. Exercise (25 min)

The facilitator gives participants different scenarios and presents them with 3 tasks:

1. Calculate the square meters of field that you will need to have collect 25 tons of your crop
2. How much water and fertilizer you will need to maintain the crops?
3. Calculate the area of storage that would be needed

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Scenario 1

You have a farm dedicated to plant corn for the life stock food.

Figure 1: Wikimedia Commons

Details about the crop:

- One plant of corn can give 3 cobs.
- Its development time is 6 months (planting in March and crops in September).
- To crop 1 ton of corn farmer needs to plant 80 thousand seeds/ha
- 1000 seeds weights 2 kg

Hydration needs: First 3 months: 2 times a week / around 15 ml/m2 then once a week.

Fertilization: every 2 months, 1,5 kg of fertilizer for a 250 kg of seeds

Storage needs:

Corn can be stored in cylinder shape silos. One silo can hold 5 kg/m3

You have a 12m diameter and 18m high silos. How many silos you need to store all your crops?

Important: Corn needs to be dried before long term storage and during this process it loses 15% of its humidity volume.

Scenario 2

You have a farm dedicated to have brussels sprouts for the chain of eco shops.

Figure 2: Rynek Rolny

Details about the crop:

- One bush can grow around 60 pieces
- To crop 1 ton of brussels sprout, farmer needs to plant 2000 plants/ha
- Its development time is 5 months (planting in April and crops in September).
- One brussels sprout weighs 16 g

Hydration needs: First 3 months: 1 time /week around 50 ml/m2 then 2wice a month.

Fertilization: 3,3kg of fertilizer to produce 1 ton. Brussels sprouts needs fertilization twice: 2 weeks after planting and week before harvest in August.

Storage needs: 30% of the crops are sold right after harvest. As brussels sprouts keeps it nutrition characteristics after freezing the farm is freezing the rest of the crops in boxes that contains 20 kg of brussels sprout. How many boxes you need to contain all brussels sprouts that were not sold right away?

Information for the facilitator

Subject: Examples of additional tasks

Instructions: Depending on the level of engagement you can add additional tasks to both of the scenarios.

- There was a heavy rain this year. You lose 15% of the crops. How many tons you will have in the end?
- There is a new legislation in your country that allow farmers to a grant of 200 euro per square meter of their field. How much many you would receive?

Information for the facilitator

Subject: Answers for question 1: Calculate the square meters of field that you will need to have collect 25 tons of your crop.

- **Scenario 1:** To crop 1t of corn, farmer needs to plant 80 thousand seeds/ha, therefore, to crop 25t the farmer would need to plant 2 million seeds and that requires 25ha which is 250 000 m2.

- **Scenario 2:** To crop 1 ton of brussels sprout, farmer needs to plant 2000 plants/ha, therefore to crop 25t the farmer would need to plant 50 000 seeds and that requires 25ha.

Information for the facilitator

Subject: Answers for question 2: How much water and fertilizer you will need to maintain the crops?

- **Scenario 1:**

  Fertilizer: 1,5kg of fertilizer is needed for 250kg of seeds. 1000 seeds weight 2 kg. To crop 25t of corn farmer needs to plant 2 milion seeds which weights 4000 kg. That means that for one fertilization process farmer needs 24kg. As the process needs to be done 3 times, the farmer needs 72 kg of fertilizer.

- Water: 15 ml is needed for 1m2 of the field. So to water whole field farmer needs 3750 liters of water. For the first 3 months it needs to be done twice a week (8 times per month). 3 x 8 x 3750 = 90 000 liters of water for the first 3 months.

  Then it can be watered once a week (4 times in month). 3 x 4 x 3750 = 45 000

  In total for the whole plantation farmer needs: 45 000 + 90 000 = 135 000 liters of water

- **Scenario 2:**

  Fertilizer: 3,3kg of fertilizer is needed to produce 1t of plants. That means that for one fertilization process farmer needs 82,5 kg. As the process needs to be done 2 times, the farmer needs 165 kg of fertilizer

  Water: 50 ml is needed for 1m2 of the field. So to water whole field farmer needs 12 500 liters of water. For the first 3 months it needs to be done once a week (4 times per month). 3 x 4 x 12 500 = 150 000 liters of water for the first 3 months.
  Then it can be watered 2 times a month. 2 x 2 x 12 500 = 50 000

  In total for the whole plantation farmer needs: 50 000 + 150 000 = 200 000 liters of water.

Information for the facilitator

Subject: Answers for question 3: Calculate the area of storage that would be needed.

- **Scenario 1:**

Cylinder volume: V = π * r2 *h

r - radius

h - height

One silo can hold 2035.75 m3 in total.

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One silo can hold 5kg/m3

1357,17 m3 x 5 = 6785,85 kg = 6,8t (rounded)

Farmer cropped 25t of crops but as they dry they loose 15% of volume, so he/she needs space for 21,25t (25 x 0,15 = 3,75, 25-3,75= 21,25t)

21,25t require therefore 3,125 silos.

- **Scenario 2:**

30% of harvest is sold right away. Whole harvest is 25 000 kg and 30% is 7500, therefore 25 000kg – 7 500kg = 17 500kg

One box contains 20kg. For 17 500kg of brussels sprouts that were not sold farmer needs 875 boxes.

4. Debriefing session (10 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: After solving the exercises the facilitator poses debriefing questions.

- How this experience changes your perspective on the questions asked in the warm up?
- How you think technology can help to support farmers in this task?
- Where else can you see appliance of mathematics in agriculture?

5. References for activity 3

Joanna Żołnierkiewicz "Brukselka uprawa odmiany i wymagania" (2020) Rynek Rolny 16.09.2020 from https://www.rynek-rolny.pl/artykul/kapusta-brukselska-brukselka-uprawa-odmiany-i-wymagania.html

Wikimedia Commons (2.08.2020) Corn field. Retrieved 31.08.2020 https://commons.wikimedia.org/wiki/File:Agriculture_-_Corn_FIeld_(45691292921).jpg

Activity 4 - Building a farm

- **STEM field:** Engineering
- **Indicative calendar:** In spring, when the seeding process starts on farms
- **Activity duration:** 60 minutes
- **Type of activity:** Indoor workshop
- **Educational objectives:**

  The objective of this activity is to discuss certain aspects of the farm planning.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:

  - improved their teamwork skills

  - acquire basic knowledge on how to plan different features of the farm

- **Required material and resources:**

  Flip chart paper sheets (as a base for building), markers and bloc boxes (ex. Lego) 1 box for each team, plasticine.

Training sessions

Note: The amount of people ideal for this activity is 2-3 teams of 4-6 people (gives 8-18 people).

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1. Preparation (5 minutes)

Information for the facilitator

Subject: Introducing the activity

Instructions: The facilitator plays the role of EU representative that judges the competition "Smart FARM prototype" and needs to communicate the following messages:

1. All teams will be building a single product – a SMART FARM that uses one of the chosen technologies (how does it work they can use their imagination 😉)
2. The SMART FARM with certain features.
3. The main building elements are blocks, though any other material can be used in addition.
4. The facilitator will be involved in the development process by being available to answer questions and provide feedback.

2. Main session (10 minutes)

Once the facilitator has explained the rules and agreed on the process, it is the time to share the features of the farm. The facilitator can do it by the showing a team pre-prepared set of sticky notes hanging on a sheet of flip-chart paper. It is advised to keep it visible for all the teams to see.

The farm should include the following items:

- 2-3 one store building
- water tank
- storage for the tools
- some farm equipment
- house for the farmer family
- field for animal feed vegetables
- storage for the fertilizer
- field for the vegetables to sell on the market
- storage room for crops
- river (can be drawn)

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List of technological tools that participants can choose from:

- microchips for monitoring the plants
- modern hydro station
- solar power
- fertilization system
- wind power plant

Participants can choose one technological tool.

3. **Exercise (30 minutes)**

Building Process

The teams use the flipchart as the base of the farm and all the materials are provided by the facilitator.

Following this, each team makes a short 3 min presentation about their creation and the solutions they have used.

4. **Debriefing session (5-10 minutes)**

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the presentation, the facilitator poses some debriefing questions.

- What was challenging in this experience?
- What would you do different if you started again?
- What technology could be helpful to create better farm?

5. **References for activity 4**

Plays in business (12.09.2015) LEGO Scrum City game. Retrieved 16.09.2020 https://www.plays-in-business.com/download/lego-scrum-city-gaming-instructions/

Activity 5 - Perma-venger hunt

- **STEM field:** Biology
- **Indicative calendar:** Spring to autumn – as long as it's okay for participants to stay outside
- **Activity duration:** 60 minutes (depending on the size of the farm and the number of items participants need to find)
- **Type of activity:** Outdoor workshop
- **Educational objectives:**

  The objective of this activity is for participants to be able to describe how the life on farm looks like and how it operates.

- **Learning outcomes and acquired competences:**
  By the end of this activity, participants will:
  - have explored the farm environment at their own pace.
  - gain a better knowledge of what is produced on the farm through the "plant card".

- **Required material and resources:** Printed sheet for the scavenger hunt, sheets of paper and a reward.

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Training sessions

1. Preparation

Information for the facilitator

Subject: Preparation of the cards

Instructions: The plant cards and the scavenger map are only examples and you don't have to follow them 1:1. It can be easily adapted to your needs and resources that the farmer has.

PLANT CARD EXAMPLE:

PLANT CARD TO PRINT

2. Main session

Information for the facilitator

Subject: Description of the activity

Instructions: This activity can be done individually or in small groups (max. 3 people). The decision is up to the facilitator.

1. Before the activity, the facilitator prepares a list of items that players need to find. It can be a variety of things: piece of equipment, product produced on the farm or a specific plant. Some of the objects can be hidden in various places in the farm, some of them are already there and it's up to participants' imagination to find them.
2. Depending on the size of the facility, the facilitator sets the time needed to complete the hunt. Suggested maximum is 1 hour.
3. If the participants are young or the farm is very big, the facilitator could mark the objects in color so they will know that they found a clue.
4. To make the hunt more educational, the facilitator prepares the "plant cards" that will contain information about the vegetables or fruits that can be found on the farm. The cards should be available for participants to take home.
5. The facilitator prepares a reward for the winner (or winning team of the hunt). This will be an extra motivation to complete the activity in time. She/he can choose anything they want as the prize, having in mind the ages of the players. For example, it can be a basket of products from the farm, a voucher for a cooking lesson or free lesson on horse riding.
6. When the time for the hunt has run out, the facilitator signals the participants to let them know that it's time to gather back.

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For exercise with the participants
Subject: Participating in the scavenger hunt

Instructions: Find all the items on the list

FARM SCAVENGER HUNT

Hints: As you will discover each item, draw or write what you found in the box. Feel free to take pictures of your discoveries, and take plant cards with you but leave rest of the items where you found them so other fellow hunters can enjoy them too.

○ Plant card 1	○ A flower that bee can land on	○ Feather
○ Tool for planting	○ Plant card 2	○ Part of hydration system
○ Vegetable bigger than your hand	○ Farm equipment	○ Plant card 3

Name:	Team:

3. References for activity 5

Plant cards: Erasmus+ Living STEM project (2020, September 28) https://www.livingstem.eu/en/resources/deck-of-cards/

WikiHow (15.03.2020) *How to create a scavenger hunt.* Retrieved 16.09.2020 from https://www.wikihow.com/Create-a-Scavenger-Hunt

Activity 6 - Sustainable Cooking Class

- **STEM field:** Biology, Ecology
- **Indicative calendar:** Any time of the year
- **Activity duration:** 60-90 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives:**

  The objective of this activity is to raise awareness of participants on how a person's eating habits affect humans' health, the environment and the whole planet, so as to improve these and urge youth to consume more responsibly and sustainably.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:
  - learn about Sustainable Development Goal 2
  - understand the cycle of sustainable cooking
  - gain knowledge on how sustainable cooking attitudes can be developed
  - enhance their critical thinking skills

- **Required material and resources:**

  Internet access, notebooks, post-its, pens, flipchart and markers, copies of the case study.
  For the exercise "Practice what you preach" consider needing: Cooking pan/ pot, stove, turner, seasonal vegetables, aromatic herbs, salt, pepper, olive oil, water.

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Training sessions

1. Preparation (5 minutes)

Prior to the workshop, the facilitator prepares some questions, so as to introduce the participants to the subject of the activity.For instance:

At the beginning of the workshop, the facilitator asks the participants to sit in a circle

- How often do you or other family members cook at home? For how many people?

- Is cooking something you enjoy? Why is that/ Why not?

- Do you have any special dietary restrictions? If yes, how do these shape your consuming habits?

- How do you procure your ingredients? Do you go grocery shopping at the supermarket, at the local market, at a farm etc.?

- Do you consume based on standards that would prevent you from buying a product? (ex. If you are trying to reduce your use of plastic and a product is wrapped with single use plastic, would you still buy it?)

and poses these questions to the group to spark a discussion.

2. Main session (15 minutes)

The facilitator formally introduces the subject of sustainable cooking by giving the definition of the notion and explaining its importance on a personal, communal and global level.

This exercise can also be done by dividing the participants in 3 groups and asking them to research the above or by addressing the following questions to the participants, which can be discussed in plenum.

- What do you think sustainable cooking is? Is it something that begins in the kitchen?

- Why is it important to cook sustainably? How does it affect you/ the environment/ the planet?

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Information for the facilitator

Subject: Definition of sustainable cooking

Sustainable cooking is a way of preparing a meal in a way it benefits one's health, environment and, ultimately, the whole planet" (Marcovic, 2018). Sustainable cooking is not something that necessarily starts in the kitchen, when all ingredients are already in the pan. On the contrary, this is a process that involves every step from:

- **Production**: Was the product made with organic/ permaculture or conventional methodologies? Where preservatives and/or chemical pesticides used?
- **Packaging:** Is the product wrapped in one-use plastic or an eco-friendly packaging?
- **Traveling**: Is the product local or has it traveled from the other side of the world to get to you?
- **Sourcing**: Has the product been procured from a local market, a farm or a supermarket? Do farmers work under fair and safe conditions?
- **to Cooking**: How much energy, water has been spent to cook a meal? Do you buy local, seasonal and environmentally friendly food? Do you cook healthy food or food in a healthy manner?
- **Consumption:** Products like meat and dairy require more resources and energy to be produced than vegetables, leading to more greenhouse gas emissions, a less rich fauna and a greater carbon footprint. Additionally, consuming fruits, vegetables and grains leads to improved personal health. Lastly, buy according to your needs and not your impulses.
- and **Waste**: How are leftovers repurposed? Furthermore, recycling and composting can reduce the amount of waste in landfills and climate impact.

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The above are determining steps in the process of cooking more sustainably. Steps in which the consumer- when cooking at home, rather than buying ready-made food- has every right to make a choice that will have a positive impact on the environment, from shopping more sustainable ingredients to reducing food waste. Because "food should not be a threat to sustainability, but a source of sustainable development" (#recipe4change, n.d.). In this way, by modifying our manner of cooking, we can contribute also to achieving zero world hunger (Sustainable Development Goal 2).

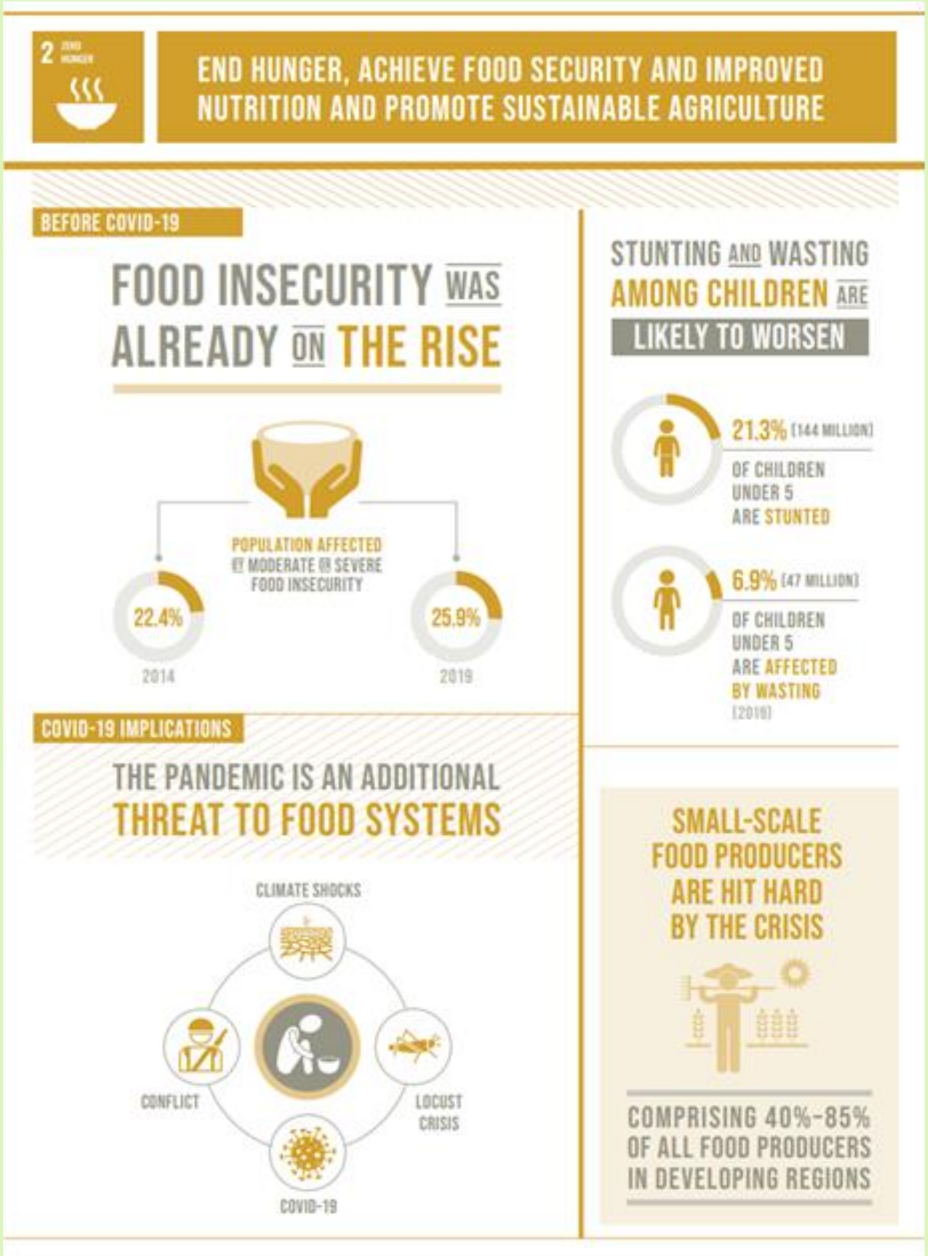

Figure 1: UN, 2020, p. 7

3. Exercises (40-70 min)

For exercise with the participants

Subject: Group research

Instructions: The facilitator divides the participants in 3 groups and asks them to research online and discuss. The participants can take 15-20 minutes, after which they will present their findings to the entire group.

A. Think of other advantages or disadvantages that the change in mentality towards cooking can have on:

- A personal level;
- A communal level;
- A global level;

B. Are any local/ national/ global initiatives that support the notion of "sustainable

Information for the facilitator

Subject: Examples of sustainable cooking advantages

Figure 2: Kaufmann, 2017

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For exercise with the participants

Subject: Case study
Instructions: The facilitator asks the participants to sit in the circle and presents the following scenario to the group. The participants will have 15-20 minutes to adjust the scenario, so that it presents more sustainable cooking behaviours.

Scenario:

It's briefly after New Year's in central Europe and Daniel is having his friends over for a housewarming. He would like to cook something special, but easy in his new brand kitchen. He chooses to cook **ratatouille** and goes to the supermarket with his shopping list (image 3), although a local market is two streets away. As the season for the vegetables of the recipe is summer, he has the option to buy frozen veggies or imported ones from Latin America. He opts for the second option and on his way to the cashiers, grabs also a bottle of red wine vinegar, although he already has apple cider vinegar at home.

Ingredients

- 2 large aubergines
- 4 small courgettes
- 2 red or yellow peppers
- 4 large ripe tomatoes
- 5 tbsp olive oil
- supermarket pack or small bunch basil
- 1 medium onion, peeled and thinly sliced
- 3 garlic cloves, peeled and crushed
- 1 tbsp red wine vinegar
- 1 tsp sugar (any kind)

Figure 3: Good Food, 2006

With quite some delay he gets home, where follows the instructions of the recipe. He fills up his pots with water and sets the stove to maximum heat to make up for the missing time. He chops his vegetables, disposes the stems to the bin and cooks them. As a final touch, once the meal is ready, he puts it in the oven to keep it warm.

When his guests arrive, they go through the meal with enjoyment and finish most of the dish, leaving only half a portion. Later on, as Daniel cleans up, he decides that the leftovers don't suffice to make another meal, so he disposes them in the bin and goes to rest.

=> Could you point out any positive or negative behaviours in relation to sustainable cooking that Daniel exemplifies? Can you think of any habits Daniel could change, in order to cook more sustainably?

Information for the facilitator

Subject: Potential solutions of the exercise

Positive behaviours	Negative behaviours	Habits to change
The recipe requires only plant-based products.	Daniel visits the supermarket, instead of the local market, even though he has the option.	Instead he can visit a local market or a farm.
Daniel prepared a shopping list.	Daniel buys vegetables from across the ocean, that have travelled for a few days and have probably been chemically preserved to keep their freshness.	Instead he could modify the recipe to adjust to local and seasonal ingredients.
Daniel bought most of his ingredients based on the list, reducing his expenses and buying based on his needs.	Daniel buys another bottle of vinegar.	He could have used the apple cider vinegar he already has at home.
	Daniel fills up his pots with water and sets the	He could have required less resources and

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	stove to the maximum. In the end, he also uses the oven.	energy, had he used less water, reduced the stove heat and switched off the oven.
	Daniel disposes the stems of the vegetables and the rest of the meal in the bin.	Daniel could replant the stems to create his own garden. He could have served the remaining food with a side dish. Alternatively, he could compost any leftovers and recycled any other containers of ingredients.

For exercise with the participants

Subject: Practice what you preach!
Instructions: If the workshop is taking place at a farm, the facilitator can dedicate another 30 minutes on a cooking activity.

As part of the field visit at a farm, the participants along with the facilitator can collect their own seasonal ingredients and prepare a delicious recipe of their choice on the spot based on sustainable cooking principles.

4. Debriefing session (5 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the workshop, the facilitator poses some debriefing questions.

1. Has your experience at the workshop changed your perspective regarding the questions asked in the warm up session?

2. Do you think that you can use what you learned today in your daily life?

3. Can you point out a couple of sustainable cooking principles that you would like to adopt now, if any?

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Activity 7 - Creating your own community garden

- **STEM field:** Science, Biology: Botany, Ecology, Permaculture
- **Indicative calendar:** Any time of the year, depending on the selected plants
- **Activity duration:** 130 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives:**

  The objective of this activity is to teach participants about the process of planting, growing and harvesting various vegetables and herbs based on permaculture methodologies with the aim of creating their own community garden.

- **Learning outcomes and acquired competences:**

  By the end of this activity, participants will:
  - acknowledge the benefits of a community garden
  - learn about permaculture methodologies and polyculture design
  - gain knowledge the basic needs of various plants (sun and water requirements, planting soil, planting depth etc.)
  - cultivate their sense of responsibility
  - develop their research skills, autonomy skills, analytical and critical thinking skills
  - have created their own community garden

- **Required material and resources**

  Internet access, notebooks, post-its, pens, flipchart and markers, gardening tools (trowel, rake, gloves), improvised boxes or pots, various kinds of soil, availability of sunlight and water, seeds (subject to change depending on which the participants will choose to plant)

1. **Preparation (10 min)**

Before the workshop, the facilitator prepares some questions to introduce the participants gradually to the subject of the activity. Also, the facilitator can bring seasonal vegetables and herbs to show to the participants. For instance:

- Do you have any experience with gardening? If yes, what have you planted so far and where?
- Can you name some of the vegetables and herbs you see here?
- Do you think there are benefits to growing your own plants? Yes/No and which are those?
- Are you familiar with the concept of a community garden?

At the beginning of the workshop, the facilitator places the vegetables and herbs in front of himself, asks the participants to sit in a circle and poses these questions to the group to spark a discussion.

2. **Main session (60 min):**

The facilitator introduces the three main concepts of the activity (i.e. community garden, permaculture, polyculture) to give the students some background.

For concepts that are not very technical, like community garden, the facilitator can divide the participants in groups to discuss questions like the following ones, before asking them to share their ideas in plenary discussion.

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- What do you think a community garden is? Are you familiar with the concept? How do you picture it?

- What are the differences between an average garden and a community garden?

- Can you think of any benefits or drawbacks of the concept of community garden?

Information for the facilitator

Subject: Definition of a community garden

A **community garden** is a shared plot of land, where a group of people (often from the surrounding neighbourhood) grow and harvest together fruits, vegetables and flowers for the benefit of the group and the wider community. This concept is all about sharing- both the work and the final produce, so it attracts people of different age groups and cultures.

A community garden can be structured in many ways (ex. planting directly in the ground (Figure 1), in raised beds (Figure 2) or in the garden of a public space, like a house of worship) and can address different needs, meaning that the harvest can serve the gardeners and the community or it could be sold at the local market and used at restaurants).

Figure 1: Merton, 2015

Figure 2: Urban Abroad, n.d.

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Another feature that makes every community garden unique is the set of “ground rules” that underpins them. The ground rules are a form of agreement between the garden participants on how the community garden will be managed and operated, which has to be respected by all members. For instance, after the location of the garden is selected, the members can decide if they would like to grow vegetables, herbs, fruits and flowers or only one/some of the above, if they will use conventional gardening or permaculture methodologies (ex. if they will use chemical fertilizers or compost) and how to rotate responsibilities between the members of the group, among others. As the nature of a community garden is based on collectivity, cooperation and inclusion, the voices of all participants deserve to be heard when taking such decisions.

For exercise with the participants

Subject: Creation of a community garden “contract”
Instructions: The facilitator asks the group and makes a note of the “contract” on the flipchart.

What ground rules would be important for you in a community garden? Name up to 10 examples.

Information for the facilitator

Subject: Example of a community garden “contract”

Figure 3: Noteful Living, 2020

Information for the facilitator

Subject: The benefits of a community garden

Instructions: The facilitator presents to the participants potential benefits from starting a community garden project.

Community gardens are an immensely valuable resource to neighbourhoods and entail a number of benefits:

- An open, green space that contributes to an improved quality of life;
- A place for hosting recreational, therapeutical and educational activities relating to physical exercise, stress-relieving exercises and agricultural practices;
- A spot to grow organic food in a sustainable way, thus developing a culture of self-sustainability (McGuire, n.d.) and healthy eating habits;
- Through social interaction neighbours create a sense of connection and community, which in turn helps to prevent crime (Merton, 2015), creates intergenerational links and raises intercultural awareness;
- The participants gain skills on the cultivation of plants, which can have a mentally stimulating effect (personal satisfaction);
- Community gardens contribute to a cleaner, cooler environment in comparison to paved areas, as plants add oxygen, reduce air pollution, absorb rainwater and are ideal for composting;
- They increase pollination between plants, which is beneficial for bees and other endangered pollinators (McGuire, n.d.).

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Information for the facilitator

Subject: Permaculture practices

Instructions: The facilitator can stick the following four quotes on the flipchart to give the participants an initial idea about permaculture.

"Permaculture offers ways we can design human habitat, places for people to be, that work with nature." (The basics: What is permaculture, n.d.)

"One of the most important things about permaculture is that it is founded on a series of principles that can be applied to any circumstance—agriculture, urban design, or the art of living. The core of the principles is the working relationships and connections between all things."

— Juliana Birnbaum Fox, Sustainable Revolution: Permaculture in Ecovillages, Urban Farms, and Communities Worldwide (Permaculture quotes, n.d.)

"Cultures throughout the world and throughout history that developed stable, sustainable relationships with nature did so through observation—a primary principle in permaculture."

— Juliana Birnbaum Fox (Permaculture quotes, n.d.)

"Permaculture land-use ethics invite us to protect intact ecosystems where they remain and, where ecosystems have been destroyed, to help restore them. Permaculture design also suggests that we take care of earth while taking care of people."

— Juliana Birnbaum Fox (Permaculture quotes, n.d.)

Information for the facilitator

Subject: Definition of permaculture

Instructions: The facilitator helps the participants come up with a definition of permaculture, based on the above quotes and any background knowledge.

Example of definition:

The word permaculture derives from **"permanent agriculture"** and is a design approach on agriculture, which draws on our understandings of how nature operates (The basics: What is permaculture, n.d.)

Permaculture has 3 ethics and is based on 12 design principles:

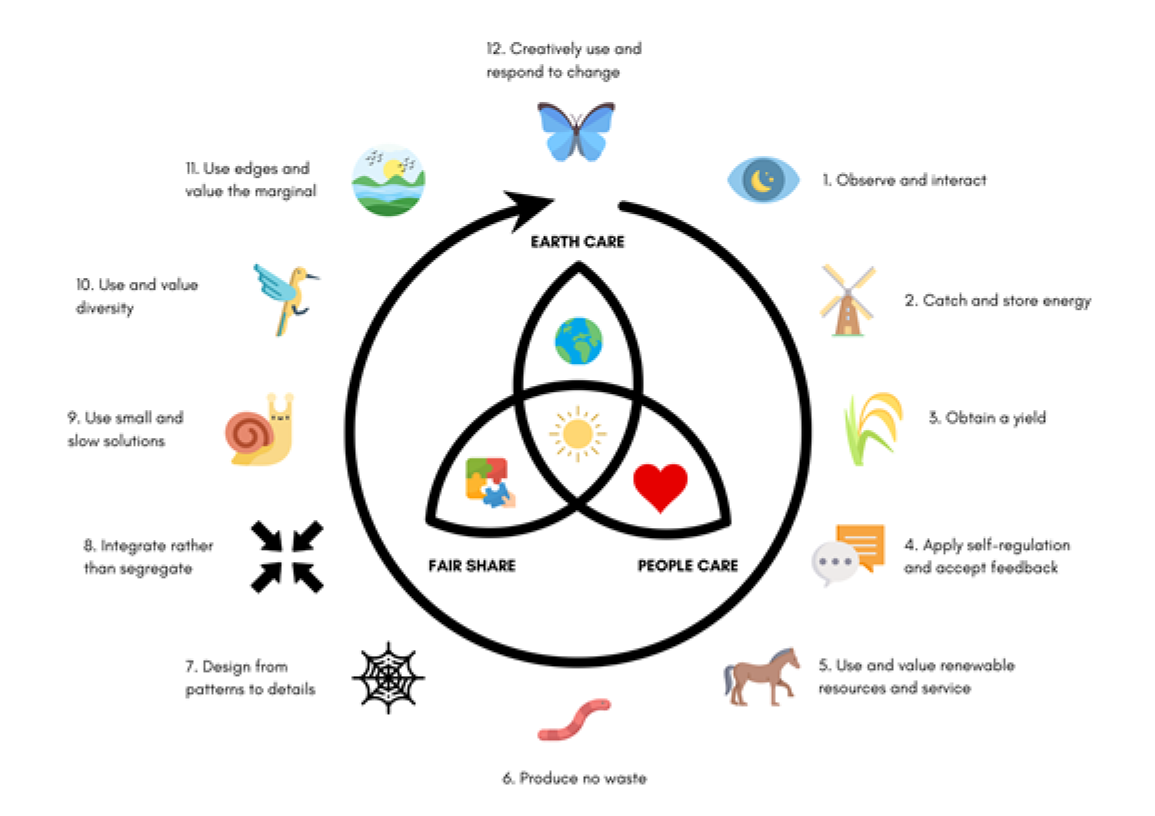

Figure 4: Twelve principles of permaculture

For exercise with the participants

Subject: The application of permaculture principles in daily life practices
Instructions: The participants answer the questions below through a plenary. discussion.

Can you think of how these 12 principles can be implemented in practice? How would you produce no waste in your community garden or store energy?

Information for the facilitator

Subject: Examples of applications of permaculture principles in daily life

1. Use your best spot to grow vegetables in permanent beds
2. Grow perennial vegetables and herbs that are adapted to your site, soil and climate
3. Use mulching, drip irrigation and composting to minimise water inputs and eliminate waste
4. Use renewable energies and store rain water
5. Reduce or create zero waste by composting (Pleasant, 2012)

Information for the facilitator

Subject: Definition of polyculture design

A necessary element of permaculture design are **polycultures or guilds**. In other words, the cultivation of various crops, which are "natural associates" in the same area (Polyculture Design, n.d.). This methodology is designed to optimize the management of plants, while minimizing the competition for nutrients and maximizing their ability fight off pests and diseases due to the varying colors, textures and scents of the plants. Additionally, it's a way to reduce water consumption and the amount of required space, hence why we will use it in our community garden.

In practice, just like in the example below (Image 4), a polyculture is achieved by growing seeds of different families and diverse leaf shapes, colors, textures and scents in distinct layers above and below the ground: canopy, understorey, groundcover, roots and climbers (Mixed Vegetable Gardening, n.d.). As to which plants will be selected and how those will be combined, this depends on each gardener.

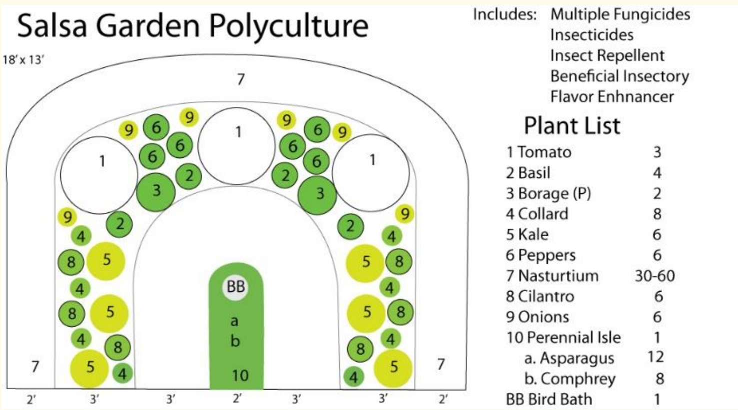

Figure 5: Salsa Garden Polyculture, n.d.

Table 1: Some plants that can be grown in different layers of the polyculture

Layer	Brassicas (cabbage family)	Legumes (pea family)	Allium (onion family)	Spinach	Composite (daisy family)	Umbellifers (carrot family)	Cucurbite (squash family)	Nightshades	Others
Canopy	Cabbage Cauliflower Broccoli Kale	Broad beans Runner beans Peas	Leek	Amaranth	Sunflowers	*Lovage*		Tomato	Sweetcorn
Climber		Runner beans					Cucumber Small squashes		Nasturtium
Understorey	Pak Choi Kohlrabi	Dwarf beans Chickpeas	Chives Onions Garlic	Spinach Chard	Lettuce *Marigold*	Coriander Fennel Dill			Claytonia (Miner's lettuce)
Ground cover (planted early)	Rocket Mustard Landcress Oriental greens	fenugreek		Amaranth	Young lettuce Lambs lettuce		Squash (late crop)		Buckwheat
Root crop	Radish Turnip		*Onion Garlic Spring onion*	Beetroot		Carrot Parsnip		Potato	

Plants shown in ***italics*** *are good to plant along the edge as well, to protect the patch from pests.*

Other crops may be possible too – these are just a few examples. Feel free to experiment! Write successes on here - and please let us know.

Figure 6: Plants that can be grown in different layers of the polyculture, n.d.

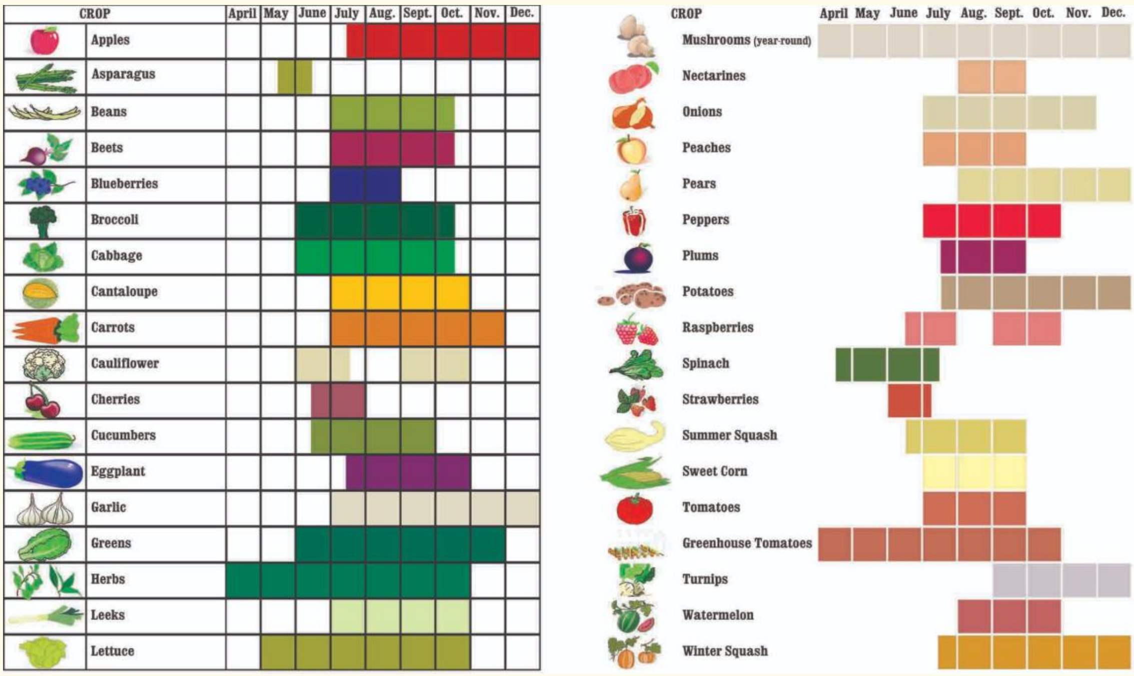

Figure 7: Handy crop calendar, 2012

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Information for the facilitator

Subject: Example of a polyculture grouping (Living STEM project, 2020)
Instruction: The facilitator can use the following example of polyculture grouping, in case the participants don't understand how to group the plants.

1. Set your goals for your community garden
2. Analyse and assess the site
3. Create a preliminary design of the site
4. Select between 2-10 types of seeds (depending also on the size of the available area) that you would like to plant, that are tolerant to the local weather conditions, that have similar management needs and meet the goals set for the garden
5. Decide on the architecture of the community garden: number and structure of the layers; type of habitat, size and forms of the plants.
6. Ensure that you are aware about the needs of every plant in sunlight, water, composted fertilizer
7. Create the irrigation, fencing, labelling of your plants

(Toensmeier, 2016)

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SEED	SPECIFICATIONS						
	Time of the year best to be planted in South Europe	**Planting soil**	**Appropriate weather/ temperature**	**Planting depth**	**Water Requirement**	**Maturation Period in days**	**Sun requirement**
DAUCUS CAROTA 	February-April OR July-August (depending on variety)	Well drained	7-30 C	0.5-1.5 cm	AVERAGE (2.5 CM EVERY WEEK)	65-70	Full sun
DILL 	March-August	Well drained	20 C	0.5 cm	AVERAGE	21-28	Full sun
SOLANUM TUBEROSUM 	February-April OR July-August (depending on variety)	Well drained	18-21 C	7.5-10 cm	Average (2.5 cm per week)	90-120	Full sun

3. Exercises (60 minutes)

For exercise with the participants

Subject: Plants' needs-analysis

Instructions: The facilitator asks the participants to name 12 types of local and seasonal vegetables, plants or flowers that they would like to plant in their community garden and divides them in 3 groups to research and complete the following table. They have 15 minutes to do so.

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SEED		SPECIFICATIONS					
	Time of the year best to be planted in South Europe	Planting soil	Appropriate weather/ temperature	Planting depth	Water Requirement	Maturation Period in days	Sun requirement

For exercise with the participants

Subject: Mix and match

Instructions: The facilitator asks the participants to group the 12 selected plants according to their size, planting depth, sun and water requirement. The participants will have 15 minutes to justify the manner in which they chose to group the plants.

Justification of grouping:

For exercise with the participants

Subject: Ready, set, plant!
Instructions: The participants have 30 minutes to plant their guilds.

Depending on the grouping of plants, there must be at least a couple of guilds to be planted, based on which the facilitator divides the participants. The participants dig and prepare the soil.
The seeds have to planted at a fair distance between them, depending on their growth rate.
When everything is planted, the participants can use ash, rock dust or sea weed powder as a natural fertilizer. The facilitator has to ensure that the plants are covered with sufficient topsoil or compost to cover the fertilizer and seeds (Mixed Vegetable Gardening, n.d.). Once everything is set, the plants have to be watered and labeled.

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Activity 8 - A self-sustained agricultural infrastructure

- **STEM field**: Science, Technology, Ecology
- **Indicative calendar:** Any time of the year
- **Activity duration:** 60 – 90 minutes
- **Type of activity**: Indoor and outdoor workshop
- **Educational objectives:**

  The objective of this activity is for participants to learn about the innovations that can make an agricultural infrastructure self-sustained in terms of crop, water, waste, animals and energy resources. Furthermore, to understand how the technological innovations can reduce energy consumption and assist in making a farm self-sustained.

- **Learning outcomes and acquired competences**

  By the end of the activity, participants will:

  - Learn about self-sufficiency and self-sustainability
  - Understand sustainable agriculture and farming
  - Gain knowledge on how a farm can become self-sufficient
  - Understand the importance of self-sustainability
  - Enhance their critical thinking and autonomy skills

- **Required material and resources:**

  Notebooks, pens, copies of the group research exercise

Training sessions

1. **Main session (25 min)**

Before starting the workshop, the facilitator will formally introduce the subject of self-sufficiency and self-sustainability as well as the difference between the two and how they can be combined. This exercise can be done in the form of a discussion between the facilitator and the participants by addressing questions to them, such as:

- What do you think that the definition of self-sufficient and of self-sustained is?
- What is the difference between them?
- Can someone think of a definition for sustainable agriculture / farming?

Information for the facilitator

Subject: Definition of self-sufficiency and self-sustainability

Self-sufficiency can be defined as the ability to provide or supply one's own or its own needs without external assistance or the help of other people.

Self-sustained can be defined as the ability to continue in a healthy state without outside assistance. A type of sustainable living can be when nothing is consumed other than what is produced by self-sufficient individuals. Self-sustainability may require an understanding of the economic, environmental, social and cultural impacts of decision making.

Moving on to the difference between self-sufficient and self-sustained: they are both overlapping states where, a person or organization needs little or no help from others or even some interaction with them. Self-sufficiency involves the self being of individuals to fulfill their needs, and therefore, a self-sustained entity can maintain self-sufficiency indefinitely.

A system can be considered as self-sustained or self-sufficient if it maintains itself by independent effort. A system's self-sustainability can be measured as:

- The degree at which the system can sustain itself without external support
- The fraction of time in which the system is self-sustained

What can be meant by **sustainable agriculture**? It is a combination of plant and animal system practices that in the long term will be able to satisfy human food and fiber needs as well as enhance an environmental quality and the natural resource base upon which the agricultural economy depends. Furthermore, sustainable agriculture may sustain the economic viability of farm operations and most importantly to enhance the quality of life for farmers and the society as a whole.

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To wrap up, environment sustainability in agriculture includes:

- Building and maintaining healthy soil
- Managing water wisely
- Minimizing air, water and climate pollution
- Promoting biodiversity

A part of sustainable agriculture is sustainable farming, which can be defined as the production of food, fiber, plant or animal products without harming any natural resources or the land. This can be done by considering some social responsibilities such as working and living conditions of farmers and workers (as mentioned above), the needs of rural communities and the health and safety of the consumer.

"Sustainable farming meets the needs of the present generation without damaging the ability for future generations to meet their needs."

Figure 1: What is sustainable agriculture, 2017

Figure 2: OnePlate, 2019

2. Exercises (30-60 min)

For exercise with the participants

Subject: Group research

Instructions: The facilitator divides the participants in 3 groups and asks them to make an outdoor research at the farm by observing and identifying how the resources listed below can be used in a farm so that it becomes self-sufficient and self-sustained. Then, the participants will discuss their findings in plenary. In case it is not possible to do the research outdoors, the participants can do an online research.

- Walk around the farm and make notes on how can a farm become self-sufficient, in terms of the following resources:

A. Crop:

B. Waste:

C. Water:

D. Energy:

E. Animal:

F. Technological Innovations:

G. Climate adaptions:

Information for the facilitator

Subject: Potential solutions to the above exercise

A. Crop: produce high-yielding food; rotate crops (to stop crop disease, prevents soil erosion); have your own bee-hive; planting over crops

B. Waste: repurposing waste; compost

C. Water: saved and recycled for energy efficiency (ex. a farm could use water from nearby dams and water reserves)

D. Energy: adopt various renewable energy sources depending on the farm's location (solar, aeolic, hydraulic)

E. Animal: raising animals on pasture and letting them move freely; providing them with a well-balanced and natural diet; treated humanely by the farmers

F. Technological Innovations: can be used to replace working hands (ex. automatic irrigation system, packaging system, milking system)

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G. Climate adaptions: triple glazed windows for colder, northern climates

shading systems for armer, southern climates

H. IPM – Integrated Pest Management: mechanical and biological controls; applied systematically to keep pest populations under control while minimizing use of chemical pesticides

I. Agroforestry practices: mixing trees or shrubs into their operations; farmers can provide shade and shelter to protect plants, animals and water resources

The image below is an example of how a company in France links the cycle of life and nature by returning organic co-products to the soil. They focus on how their actions can increase the effectiveness of elaborate products, testing the impact of the company on the environment.

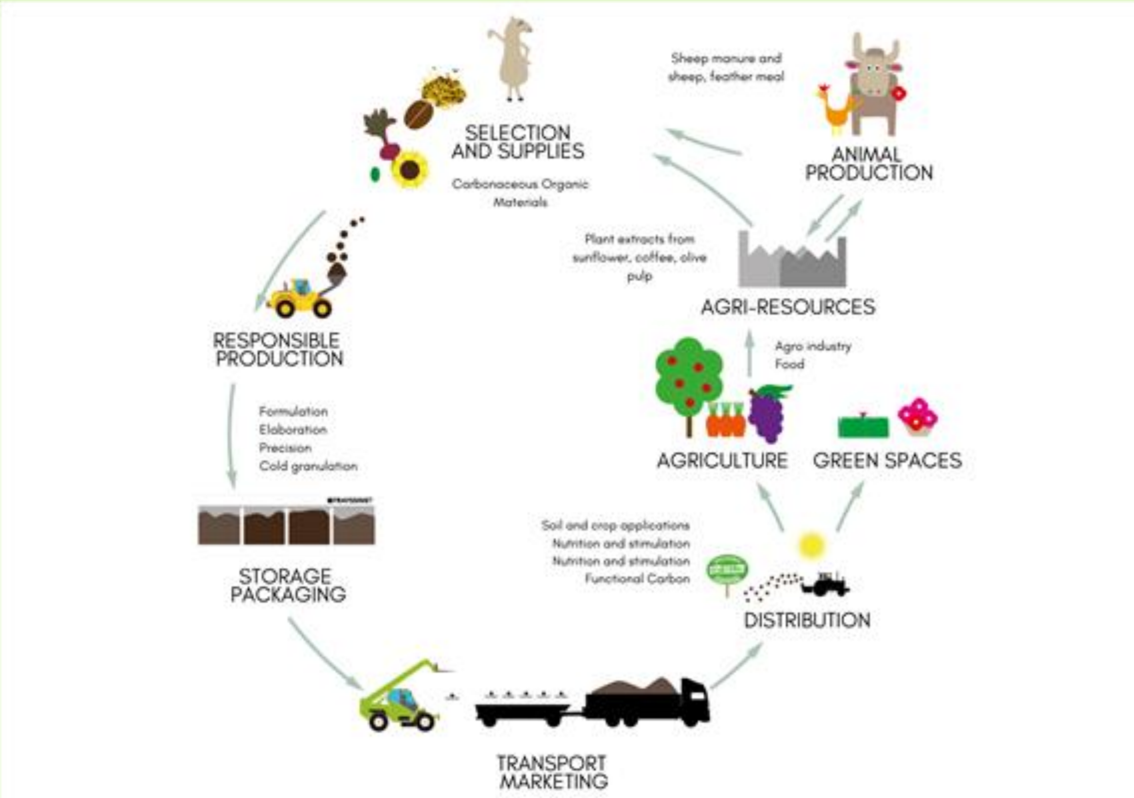

Image 3: Taking on Our Environmental Responsibility, n.d.

For exercise with the participants

Subject: Discussion on the importance of sustainable agriculture
Instructions: The facilitator discusses with the participants about the reasons sustainable agriculture is considered important nowadays. The participants should realize that most of the points of this question were mentioned by the facilitator during the main session.

Information for the facilitator

Subject: Potential answers to the discussion

Sustainable agriculture often uses a wide range of production practices such as conventional and organic. A combination of plant and animal system production practices are designed to produce long term results in the:

- Production of sufficient human food, fiber, and fuel to meet the needs of a sharply rising population
- Protection of environment and expansion of the natural resources supply
- Sustainment of the economic viability of agriculture systems

3. Debriefing (5 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the workshop, the facilitator poses some debriefing questions.

1. Have you fully understood the terms self-sufficiency and self-sustainability?
2. Do you think that sustainable agriculture and farming are developing as the years go by?
3. How do you believe farmers can be educated about sustainability?
4. Can you think of any sustainable agriculture examples that can also be used at home?

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"Sustainable Agriculture | National Institute of Food and Agriculture." (n.d.) Retrieved on September 3, 2020 from https://nifa.usda.gov/topic/sustainable-agriculture.

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"Taking on Our Environmental Responsibility | Frayssinet." Retrieved on September 3, 2020 from https://www.groupe-frayssinet.fr/en/company/sustainable-development-csr/taking-on-our-environmental-responsibility/.

"What Is Sustainable Agriculture? | Union of Concerned Scientists," (2017). https://www.ucsusa.org/resources/what-sustainable-agriculture.

Activity 9 - Operating a humidity sensor

- **STEM field:** Science, Technology
- **Indicative calendar:** Any time of the year
- **Activity duration:** 60 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives:**

  The objective of this activity is for participants to understand the importance of water management in agriculture for environmental sustainability, as well as the water needs of a soil through the use of a moisture sensor. Another objective is to gain knowledge on what a humidity sensor is and how it can be used. Lastly, the participants will learn how to evaluate the hydric needs using a humidity sensor.

- **Learning outcomes and acquired competences:**

  By the end of the activity, participants will:

  - be able to identify the importance of water management in agriculture for environmental sustainability

  - be able to identify the function of a moisture sensor and know how to use it

  - be able to identify the need for irrigation, using the soil moisture sensor.

- **Required material and resources:** 1 computer, internet access, pen and paper, YouTube video, 1 soil moisture sensor, 1 watering can with water and 3 pots with plants per group: the first pot with a plant that has not been watered for 1 week; the second pot with a plant that was watered the day before; the third pot with a freshly watered plant.

Training sessions

1. Introduction (15 minutes)

The facilitator begins by introducing the topic of the importance of water, particularly for agriculture.

Information for the facilitator

Subject: Introductory video "WATER our most precious resource"

Water is essential for the development of crops, and crops are essential for food, which in turn are indispensable for life. For a better understanding of the importance of water and the importance of its management, a video titled "WATER our most precious resource" from April 2014 will be used and is available on the YouTube platform - https://www.youtube.com/watch?v=VIaw5mCjHPI. The video is 5 minutes long and it explains the importance of water as a fundamental resource for life, but it is a finite resource. The video also covers the technological solutions that have been used to better manage this resource in the most diverse areas.

After the video, discussion follows. The facilitator asks the participants the following questions:

- How is water shared on our planet?
- Did you know that water resources are so limited?
- Do you know of any measures the agricultural sector uses for the management of water resources?
- What agricultural sector is doing the better management of water resources?
- Did you know that large amounts of water are needed for food production?
- What technologic innovations can be used to increase the available fresh water supply?

Information for the facilitator

Subject: Information on water monitoring
Instruction: The facilitator concludes the introductory session with the following data.

According to the United Nations, more than 70% of the world's drinking water is used in irrigation systems in agriculture. That is why it is important to have effective management of irrigation systems. Soil moisture monitoring has long been used in agriculture as an effective method of measuring the efficiency of irrigation and water. That device that can help to control the amount of water in the soil. The system that uses the moisture sensor will allow to measure the moisture even if the soil is apparently dry, allowing more accurate information and thus being able to monitor water consumption, reduce the light consumption that comes from the activation of a pump system for irrigation and regulate types of crops to the moisture needs of a given plantation.

Understanding the water needs of plants is also extremely important for their development. Excess and/or deficit water requirements lead to decreased productivity and quality, leaving plants more vulnerable to diseases and pests.

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Monitoring the amount of water in the soil can make a big difference in agricultural productivity by allowing a more precise way of knowing how much water is present in the soil and thus regulating an irrigation system. In this way it is possible to develop an intelligent system making it more assertive with regard to control and using information from the sensor.

We can also cross the system information with climatic characteristics of the region, knowing in a way that predicted information on rainfall, providing dates for maintenance, use of pesticides and even crops.

2. Main session (35 minutes)

Information for the facilitator

Subject: Getting familiar with a moisture sensor

Instruction: The facilitator shows a moisture sensor and explains how

The moisture sensor usually has two probes that measure the amount of water volume in the soil. The probes create an electrical current that allows the resistance to be measured. The resistance value, which varies from 0 to 1.023 (scale used in the microcontroller) from which the soil moisture value will be calculated. It should be noted that the greater the resistance detected the lower the electricity and the lower the amount of water in the soil (Soil PH 3-in-1 Tester, n.d.).

The use of this type of moisture sensor with the connection to an intelligent micro controlled system will allow good results to be obtained in the control of water and consequently in the control of agricultural production as well as energy savings.

Figure 1. Example of humidity sensor (Upgrade 3-in-1 soil Moisture Meter, n.d.)

Information for the facilitator

Subject: Outdoor session- Practical usage of the humidity sensor

Instructions: The facilitator, after explaining the composition of the humidity sensor, will explain how it works and how to interpret the data obtained. For this part of the workshop an outdoor context is needed, so that it can be more didactic and the theoretical explanation can be demonstrated in a practical context.

The facilitator explains how the sensor works. The sensor is be introduced, and the data obtained from the 3 pots should be provided. The data obtained will vary between a scale from 1 to 10: Dry(1 to 3), Moist(4 to 7) and Wet(8-10). Depending on the data obtained, there should be a decision on whether to water the plant or not. In the case of obtaining the "dry" data it means that it is necessary to water the plant/culture; in the case of obtaining the "moist or wet" data it is not necessary to water the plant/ culture. In order to consolidate the theoretical knowledge obtained, there will then be a practical activity.

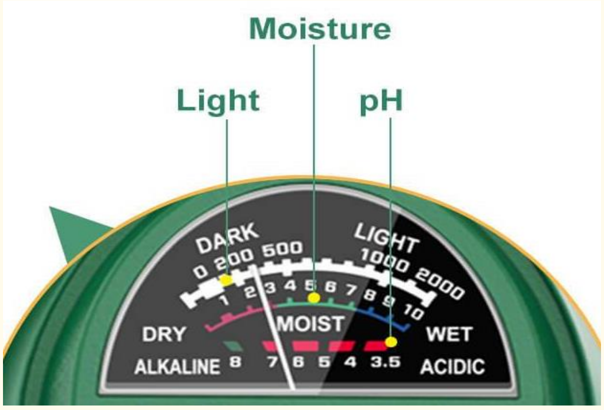

Figure 2. Moisture sensor screen - where data is shown (Upgrade 3-in-1 Soil Moisture Meter,n.d.)

For exercise with the participants

Subject: Putting the humidity sensor to test

Instructions: For the practical activity 3 pots with plants will be used. The first pot with a plant that has not been watered for 1 week. The second pot with a plant that was watered the day before. And the third pot with a freshly watered plant.

Use the sensor, as indicated above, in the three different pots and interpret the data, making the decision to water or not.

3. Debriefing session (10 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the workshop, the facilitator poses some debriefing questions.

- How important is water to agriculture?
- Why is the moisture sensor a way to promote water management?
- How can the sensor be useful in all types of agriculture, including domestic farming? Discuss it.

4. References for activity 9

Robecco Asset Management (2014, April 24). *WATER our most precious resource* [Video]. YouTube. https://www.youtube.com/watch?v=VIaw5mCjHPI;

Soil PH Tester 3-in-1 Moisture Sensor Meter Sunlight PH Soil Test Kits Soil PH Tester for Garden romote Plants Healthy Growth. (n.d.). AliExpress. https://www.aliexpress.com/item/33045231942.html?spm=a2g03.search0302.3.45.2ab735c0hmKCV4&ws_ab_test=searchweb0_0,searchweb201602_0,searchweb201603_0,ppcSwitch_0&algo_pvid=de6b73ce-1d7b-41dc-a992-2b4bf135fb82&algo_expid=de6b73ce-1d7b-41dc-a992-2b4bf135fb82-6

Upgrade 3-in-1 Soil Moisture Meter, S30, Dr.meter. (n.d.). Dr.meter. https://drmeter.com/products/s30-soil-moisture-meter.

Activity 10 - Operating a weather station

- **STEM field:** Science, Technology, Electronics, Microcontrollers
- **Indicative calendar:** Any time of the year
- **Activity duration:** 90 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives**

  The objective of this activity is to understand the importance of a weather station for agriculture. Another objective is to analyze and interpret the information provided by a weather station. A third objective is to teach participants how to operate a weather station.

- **Learning outcomes and acquired competences**

  By the end of the activity, participants will:

  - be able to identify the benefits of using a weather station in agriculture,

  - be able to analyse the data provided by the weather station (temperature, humidity, atmospheric pressure)

  - be able to use a weather station in agriculture.

- **Required material and resources:** 1 computer, internet access, a weather station.

Training sessions

1. **Introduction (45 minutes)**

The facilitator begins by introducing the topic of weather stations with some questions:

- Do you know what a weather station is?
- Do you know the uses and the purpose of weather stations in agriculture?
- What are the benefits of using a weather station for the agriculture sector?

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Information for the facilitator

Subject: Information on weather stations

Instruction: The facilitator concludes the introductory session with the following data.

A weather station, as seen in the image below (Naipal, V., 2013), is an equipment that monitors and characterizes the climatic conditions, providing the measurement of the characteristics of the surroundings, namely, measurement of the wind speed and wind direction through an anemometer in conjunction with a microcontroller.

Figure 1. Weather Station

The weather conditions that influence crops the most are **air and soil temperature, wind, soil moisture, atmospheric pressure, rainfall**. They consist of two main categories of equipment: sensors and central recorder. The sensors translate physical events into electrical and electronic signals and are responsible for quantifying several meteorological parameters, such as precipitation, relative humidity, air temperature, wind speed and direction, solar radiation (incident and reflected) and atmospheric pressure. Automatic weather stations usually operate with a central recorder, called a datalogger, which stores sensor readings and can also transmit the recorded data to a platform or web browser. Weather stations are powered by rechargeable batteries and/or solar panels.

Information for the facilitator

Subject: Video “[Update] Automatic Weather Station”

For a better understanding of the importance of weather conditions and the weather stations, a video “[Update] Automatic Weather Station” from January 2016 will be used, which is available on YouTube– https://www.youtube.com/watch?v=JviKKAydr_M.

The video is 3m30s long and refers to the influence of weather conditions on agriculture, which weather elements affect crops, what it is used for and how an automatic weather station is formed.

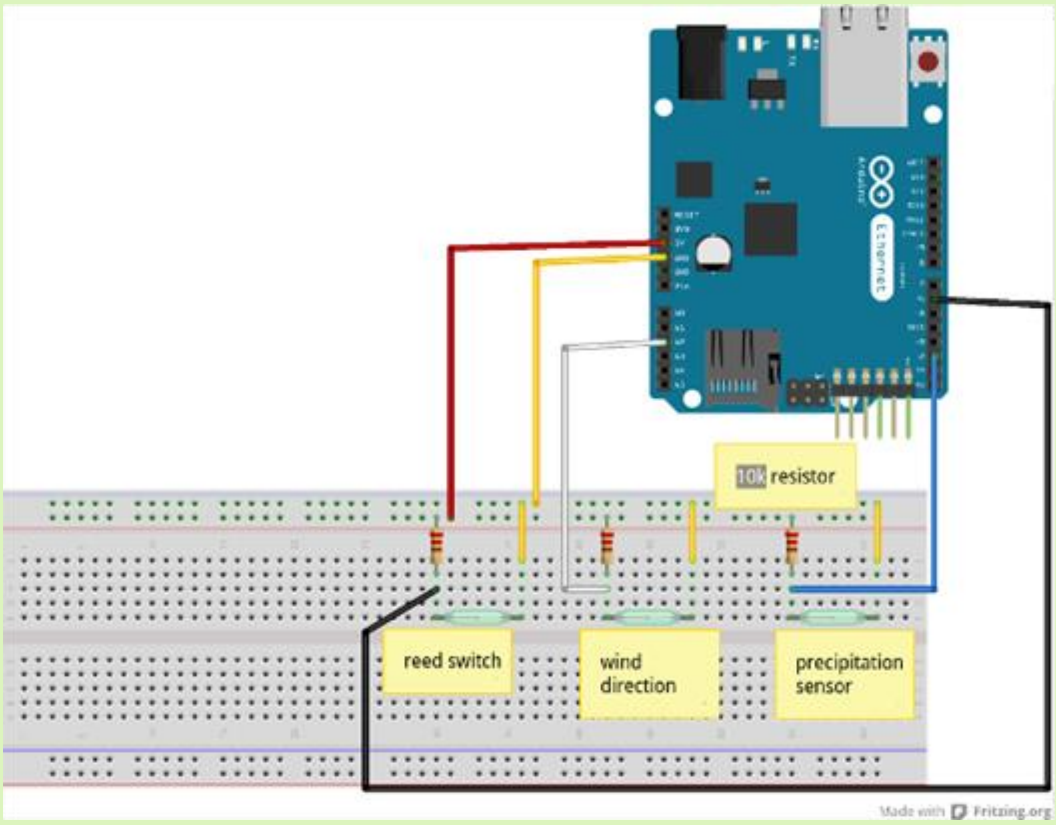

Figure 2. Weather Station connection with Arduino (Oberberger, M. 2013)

2. Main session (35 minutes)

Information for the facilitator

Subject: Outdoor session- Practical usage of the weather station

Instructions: The facilitator, after explaining what a weather station is for and its constitution, will demonstrate how a weather station is used. For this part of the workshop an outdoor context is needed, so that it can be more didactic and the theoretical explanation can be demonstrated in a practical context.

The facilitator explains how the weather station works.

This equipment has inside a reed switch (kind of switch) that contains two small separate iron plates that when touched send a signal to the microcontroller and thus be able to measure the wind speed. With this system it will also be possible to determine the wind direction through a voltage divider.

The wind direction sensor has 8 switches, 4 pointing to the cardinal points and 4 pointing to the side points of the wind rose. Each of the 8 switches has an exact value resistance for each direction and the microcontroller will read values from 0 to 1023 on the analog pin, that is, each direction has a value from 0 to 1023 without repeating itself.

This weather station will also present a rainfall system allowing to determine the volume of rainfall, which occurs in a certain area and in a certain period of time. This data will be sent to the computer and the user can monitor it in real time.

For exercise with the participants

Subject: Discussion on the importance of sustainable agriculture

Instructions: The facilitator discusses with the participants about the reasons sustainable agriculture is considered important nowadays. The participants should realize that most of the points of this question were mentioned by the facilitator during the main session.

Use the weather station to demonstrate the speed and direction of wind.

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3. Debriefing session (10 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the workshop, the facilitator poses some debriefing questions.

- How important are weather conditions for agriculture?
- What are the advantages of using a weather station in the agricultural sector?
- Although this technology is more expensive, do you think it is an investment with advantages?

4. References for activity 10

AWS Cube (2016, January 13). *[Update] Automatic Weather Station.* [Video] YouTube. https://www.youtube.com/watch?v=JviKKAydr_M

Naipal, V. (2013). [Photograph of a weather station]. https://www.researchgate.net/figure/Campbell-weather-station-with-the-different-meteorological-instruments-Hydrological_fig6_236159925

Oberbeger, M. (2013). *Wind/Precipitation*. [scheme of the connection of the meteorological sensors to the microcontroller]. Max Oberberger. https://www.maxoberberger.net/projects/arduino-weatherstation.html

Activity 11 - Measuring the pH of soil

- **STEM field:** Science, Technology, Biology and Electronics
- **Indicative calendar:** Any time of the year
- **Activity duration:** 60 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives**

  The objective of this activity is to teach the pH scale (basic, neutral and acid) and understand the importance of the soil's pH for agriculture.

- **Learning outcomes and acquired competences**

  By the end of the activity, participants will:

  - be able to classify a pH value as basic, neutral or acid,

  - know about the importance of the pH evaluation for plant development.

- **Required material and resources:** 1 soil pH measurement sensor

Training sessions

1. **Introduction (20 minutes)**

The facilitator introduces the topic of pH, by asking the participants the following questions:

- What do you think is the importance of pH?
- What do you think is the role of pH in agriculture?

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Information for the facilitator

Subject: Information on pH

Instruction: The facilitator concludes the introductory session with the following information.

The term "pH" was introduced in 1909 by the Danish biochemist Søren Peter Lauritz Sørensen. It is defined as an adimensional numerical scale used to specify the acidity or basicity of a solution. That is, it is the concentration of the hydrogen ion present in a solution. The measurement of the pH, i.e. the measurement of the concentration of hydrogen ions in a given solution is represented between the values 0 to 14, with 0 representing the most acidic solution and **14 the most alkaline**.

When the **pH value** is:

- **Between 1 and 6, it is considered acid,**
- **7, it is considered neutral;**

In the picture below, are some examples of acidic, neutral and alkaline substances.

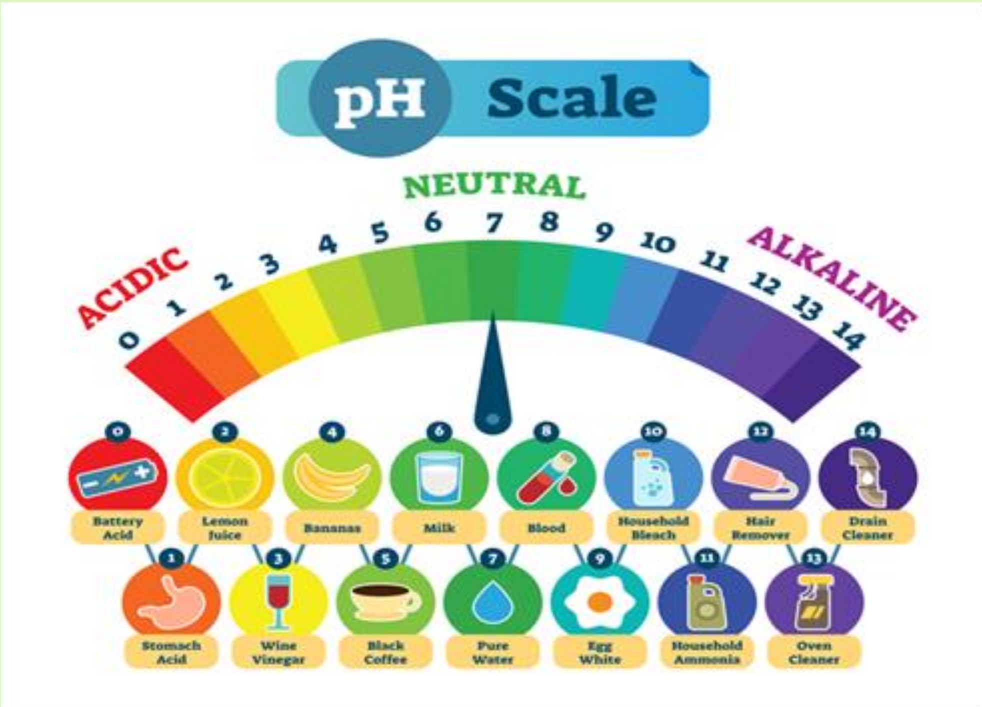

Figure 1. pH scale (Tunesi, 2020)

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The pH of water used for irrigation systems in agriculture plays a critical role in crop health and influences the effectiveness of pesticides and growth regulators.

The pH, when too acidic, can leave the leaves yellow and prevent a healthy absorption of Iron and Nitrogen. Alkaline pH, on the other hand, makes micronutrients unavailable to the plant, causing a higher incidence of disease. **Normally the plants grow best between a slightly acidic and neutral pH (between 5.5 and 7).**

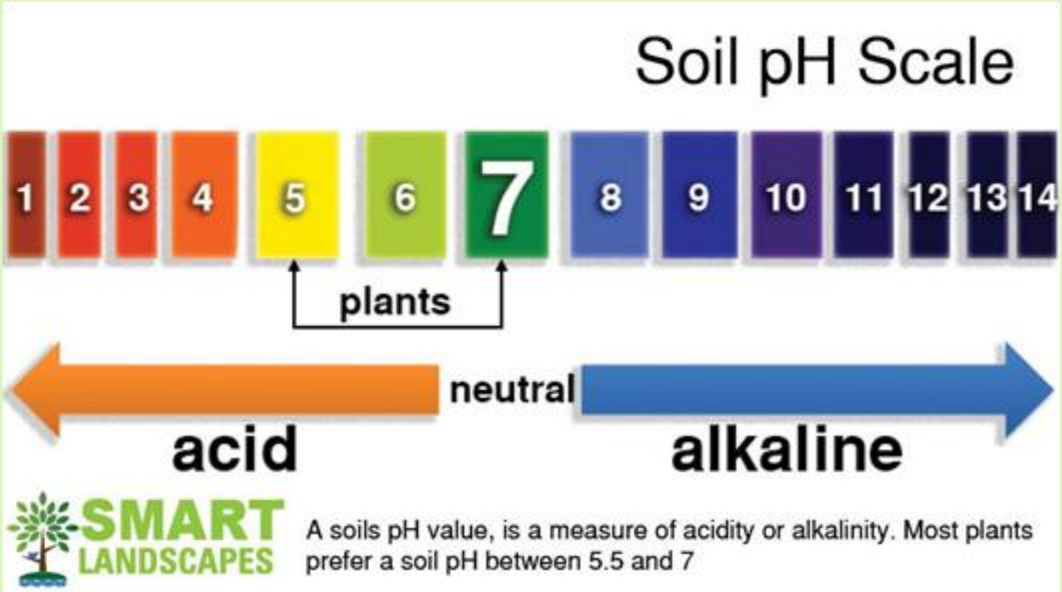

Figure 2. Plants grow best between a slightly acidic and neutral pH (between 5.5 and 7) (Mississipi State University, n.d.)

For this, it will be important that a water treatment consists of acidification or alkalinisation of its components, thus changing the proportion of Hydrogen ions. A system that can help with this analysis is the PH medication factor in the water for this we will use a pH Sensor that will send the information to the microcontroller where it will be converted between the values 0 and 14 and the user will have the real-time formation of the pH of his water. The pH of the water is a practical way of interfering directly with the pH of the soil, in addition to regulating the pH of the water, fertirrigation takes place, since the pH regulation is a system of fertilization and organic nutrition in a sustainable way.

Information for the facilitator

Subject: Getting familiar with using the pH probe

Instruction: The facilitator learns how to use the pH probe to demonstrate in turn, to the participants.

The pH probe is fixed with a protective shield similar to a lance made of stainless steel with a sharp tip. It can be drilled directly into soft semi-solid material to measure the pH value, such as wet soil or food.

Figure 3. Probe that measures the pH in the soil (Blibli, n.d.)

1. Put the probe on the ground;
2. Stick the probe into the soil about 2-4 inches;
3. Adjust the position of the probe until the pointer on the dial swings slightly;
4. After 10 minutes, take note of the pH level in the dial;
5. Remove probe from soil and wipe clean after each use.

2. Main session (30 minutes)

After explaining how the pH sensor works and the procedures to be adopted, the facilitator will divide into groups of two students in an outdoor context in the format of a workshop to observe the results obtained by the pH sensor. The facilitator will teach students how to correctly place the sensor and take the values measured by the sensor to a paper. Then the results of all groups will be analyzed, thus observing the pH quality in the soil and whether or not it is suitable for cultivation.

The facilitator, after explaining the composition of the pH sensor, will explain how it works and how to interpret the data obtained. For this part of the workshop an outdoor context is needed, so that it can be more didactic and the theoretical explanation can be demonstrated in a practical context. The facilitator should explain how the sensor works. The sensor should be introduced, and the data is observed.

3. Debriefing (10 minutes)

Information for the facilitator

Subject: Examples of debriefing questions

Instructions: At the end of the workshop, the facilitator poses some debriefing questions.

- How important is pH of plants to agriculture?
- How important is the use of the pH sensor?
- Do you think that the pH sensor can be used in all types of agriculture, including domestic?

4. References for activity 11

Blibli (n.d.). *3 In 1 Soil Tester Meter Garden Lawn Plant Pot MOISTURE LIGHT PH Sensor Tool.* [pH probe]. Blibli. https://www.blibli.com/p/3-in-1-soil-tester-meter-garden-lawn-plant-pot-moisture-light-ph-sensor-tool/pc--MTA-8293574?ds=HOL-60029-127611-00001;

McCauley, A., Jones, C., & Olson-Rutz, K. (2017). Soil pH and Organic Matter. *Nutrient Management,* 4449 (8), 1-16. https://landresources.montana.edu/nm/documents/NM8.pdf

Mississipi State Unievrsity. (n.d.). *Healthy Soils*. [soil pH scale]. Mississipi State. http://extension.msstate.edu/landscape-architecture/smart-landscapes/healthy-soils

Perry, L. (2003). *pH for the Garden*. University of Vermont Extension. http://pss.uvm.edu/ppp/pubs/oh34.htm#:~:text=For%20most%20plants%2C%20the%20optimum,require%20a%20more%20alkaline%20level

Tunesi, L. (2020). *Explainer: What the pH scale tells us*. [a pH scale]. Science News for Students. https://www.sciencenewsforstudents.org/article/explainer-what-the-ph-scale-tells-us.

Activity 12 - Composting

- **STEM field:** Technology, Engineering, Life Science, Planning Investigations
- **Indicative calendar:** Any time of the year
- **Activity duration:** 90 minutes
- **Type of activity:** Indoor and outdoor workshop
- **Educational objectives:**

  The objectives of this activity are to teach the participants about the composting procedure, and in particular that trash is composed of two types of waste: organic and inorganic. Additionally, to teach them the different between a full-loop life cycle and a linear life cycle, as well as that decomposers such as fungi, microorganisms, and insects are important in the decomposition of organic waste. The final objective of the activity is to make participants appreciate why it is important for an agro-business to have a composting machine.

- **Learning outcomes and acquired competences:**

  By the end of the activity, participants will:
  - demonstrate knowledge about the composting procedure,
  - practice asking scientific questions
  - gain experience designing an experiment to answer a question (even though it is practically impossible to conduct the experiment, due to time constraints, the participants can prepare the jars during the workshop day and keep recording their knowledge at home).

- **Required material and resources:** Computer, projector, power point presentation, relevant sources to be studied by the participants, 6 clear jars, at least one "set" of trash (e.g., an apple core, a piece of plastic, two leaves from outside, a piece of bread, a piece of tin or aluminum foil, a piece of paper), soil, enough to fill six jars (from outside, not store-bought), 1 experiment data workbook per participants and/or per group.

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Training session

1. Preparation (A few days prior to the workshop)

The experiment which is described below in details, should be carried out by the facilitator in another time, prior to the workshop (otherwise, it is not possible for the participants to run the experiment and observe the results in the time given).

During the workshop, the facilitator presents the procedure that was followed while conducting the experiment, with as much details as possible. It has to be noted, that the participants are informed in advance to bring their own material (see required material and resources above) in the workshop, so that they can start their own experiment, and keep recording their data at home.

2. Introduction (10 min)

The facilitator leads a plenary discussion with the participants, during which the main topic of the workshop is introduced. The discussion can be guided by questions, such as the following provided.

- Have you ever heard about composting?
- If yes, share your experiences.
- If not, share your expectations.

3. Main session (60 minutes)

Indoor session

Step 1 – Hypotheses formation

The participants form groups of 2-3 individuals. The activities are carried out within groups. The facilitator presents the objects (leaves, paper, apple core, bread, plastic, foil) to the participants, who are allowed to carefully observe, touch, and pick up the objects. Then, the participants are prompted to discuss the following questions along with their observations.

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- What do you notice about these objects?

- Record initial observations of each object. Make sure they include size (length, width, and height), color, shape, and a simple sketch.

- Is there anything that two or more objects have in common?

Is there anything that makes some of these objects different?

For exercise with the participants

Subject: Investigation

Instructions: The facilitator introduces the scientific practice of planning and carrying out an investigation.

You will be conducting a science experiment on trash!

In this experiment, you will see how different pieces of trash change over time. In order to conduct a scientific investigation, you can follow these steps of the scientific method:

1. ASK A QUESTION: Ask a question about something you will observe. It should start with one of these words: How, What, When, Who, Which, Why or Where.

2. MAKE A HYPOTHESIS: A hypothesis is a guess about what you think will happen in the experiment.

3. START YOUR EXPERIMENT: Your experiment tests if your hypothesis is right or wrong.

4. OBSERVATIONS: Take careful observations every week.

5. ANALYZE YOUR DATA: Using your observations, decide if your hypothesis is true or not.

6. CONCLUSION: Draw some conclusions about your analysis. It does not matter if your hypothesis is right or wrong!

The facilitator poses the following question. The participants are prompted to make a hypothesis.

How do you think these objects will change over time? Make a hypothesis.

Step 2 - Running an experiment

For exercise with the participants

Subject: Experiment

Instructions: As already noted, the experiment has been carried out by the facilitator in another time, prior to the workshop. The facilitator presents the procedure that was followed while conducting the experiment, with as much details as possible. The jars with the material added just on that day, and with the material added seven weeks ago, are shown to the participants, so that they can compare the two states of each jar and thus observe the outcomes of the experiment. The experiment is as follows.

- Place each trash item in a clean, empty mason jar.
- Try to place the item against the glass, so you can monitor it over time.
- Fill each jar to within 1 inch from the top with soil. Make sure the soil is from outside to ensure that it contains the bacteria and microorganisms necessary for decomposition. The soil should naturally contain decomposing bacteria, fungi, and microorganisms– soil bought from a store will not have these. Soil not including these decomposers will cause the trash to take much longer to break down.
- Add a few tablespoons of water to the jar and keep the lid off.
- Continue adding water to each jar as necessary to keep the soil moist but not soaked over the next seven weeks.

Optional: The participants who have brought with them the necessary material, can set up their own experiment and continue with their observations at home.

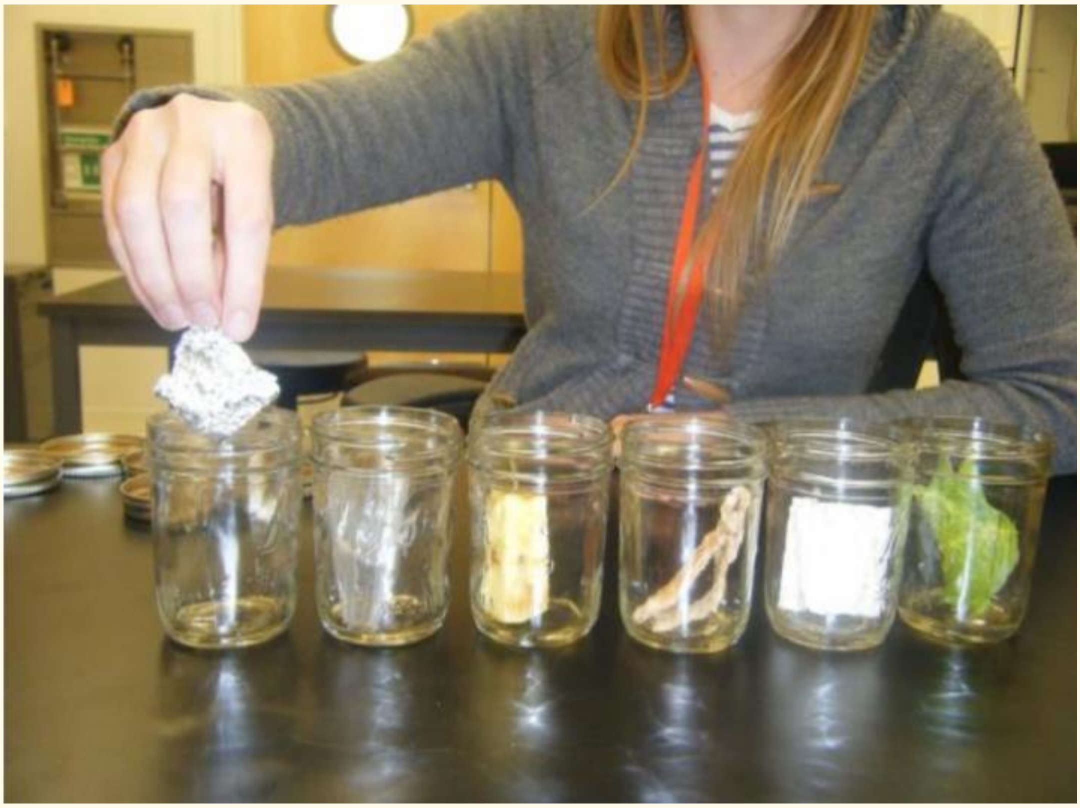

Figure 1. The experiment. Image retrieved from:
https://www.calacademy.org/sites/default/files/assets/docs/pdf/064_compostingascientificinvestigation

Step 3 - Analyze and interpret the data

For exercise with the participants

Subject: Analyze and interpret the data
Instructions: The participants are asked to record their observations and decide on whether they should accept or reject their initial hypothesis.

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Making observations

Initial state of jars:	Write your observation here:
Final state of jars:	Write your observation here:

Analyze and interpret the data

Can you accept or reject your hypothesis?

Step 4 – Conclusion

A plenary discussion takes place, guided by the following questions.

- Which pieces of trash changed the most? Why?
- Which pieces did not decompose at all? Why?
- What made these pieces different?

The term "**decompose**" is being introduced to the participants. The facilitator asks again the participants if anyone has heard this word before, and if anyone knows what it means. A list of scientific terms is provided to the participants, along with the decompose term.

Scientific terms

organic waste: waste from organisms or their life processes that can easily be broken down

inorganic waste: waste not from organisms, or from organisms that existed millions of years ago, that cannot be easily broken down

decompose: to separate or resolve into components or elements

decomposer: an organism, usually a bacterium or fungus, that breaks down the cells of dead plants and animals into simpler substances

full-loop life cycle: a life cycle for a material that never comes to an end. Examples are organic waste like food scraps or lawn trimmings that are composted and turned back into the soil from which they came.

linear life cycle: a life cycle for a material that comes to an end. For example, plastic is made from fossil fuels mined from the Earth, but its life cycle will end in a landfill.

compost: a mixture of decayed or decaying organic matter used to fertilize soil

microorganism: Micro = small, Organism = living thing. A living thing so small that it can only be seen with a microscope. These include bacteria, protozoans, and certain algae and fungi.

After going over the definition, the facilitator asks the participants if any of the experiment's objects decomposed.

The facilitator points out that not all of the objects decomposed. S/he poses the following question.

"Why do they think this is?"

Along the discussion, the definition of the terms organic and inorganic waste is being provided. The participants are asked to provide some other possible examples of each category, reflecting on their everyday experience.

"What are the differences between organic and inorganic waste?"

The facilitator asks the participants what causes decomposition to occur. S/he names some decomposers and explains why they are important.

Information for the facilitator

Subject: Organic and inorganic waste

Guiding answer: bacteria, fungi, beetles, ants, flies. All of these organisms eat decaying animal and plant matter, returning nutrients back into the earth. It may appear that matter breaks down by itself, but in reality, we just cannot see all of these organisms hard at work. Without them dead matter would never convert back into nutrients and Earth's ecosystems would not function properly.

The facilitator asks the participants what takes longer to break down – organic or inorganic waste? And why?

Information for the facilitator

Subject: Organic and inorganic waste

Guiding answer: Organic waste is made of matter that was very recently alive, like plants and animals. Inorganic matter is made of matter that was not alive, or was alive millions of years ago, like minerals and petroleum. Inorganic matter takes longer to break down because it is not decomposed by other organisms. It is left to break down on its own with the help of the sun and water, which takes a very long time, sometimes thousands of years.

The facilitator introduces the concepts of the full-loop life cycle and the linear loop life cycle. S/he asks the participants:

Guiding answer: it returns essential nutrients back into the soil. If organic waste is landfilled, it permanently removes those nutrients from the earth.

Which one belongs to the organic waste?

Which one belongs to the inorganic waste?

What are the benefits of composting for the environment?

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Step 5 – Extension

For exercise with the participants

Subject: The value of composting for an agro-business
Instructions: Once the participants have a basic handle on the concept of decomposition, the facilitator guides the discussion towards the value of composting for an agro-business. Different composting methods applied in farms (e.g., open pile composting, box composting, pit composting, trench composting) are presented.

Methods of composting at a farm

- Open pile composting,
- Box composting,
- Pit composting,
- Trench composting
  (FSDA – UNEP, 1993)

- **How can agro-business automate and accelerate the composting procedure?**

The participants are queried:

- How could the composting procedure be automated and accelerated?
- What is the value of doing so, for an agro-business?

A short video is presented, followed by a plenary discussion on the benefits and potential constraints of having a composting machine in an agro-business.

The need for composting machines in agro-businesses

Video link: https://www.youtube.com/watch?v=_85hMSllf6s

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Figure 2. A composting machine. Image retrieved from: https://greenshieldenviro.com/compost-machine-manufacturers.php

For exercise with the participants

Subject: Composting machines in agro-businesses
Instructions: Reflecting on the video, participants are asked to consider the benefits and potential constraints of operating composting machines in agro-businesses. Following a discussion on the plenary, the information below is given.

The need for composting machines in agro-businesses

- **Benefits:**
  - Segregating organic waste
  - Shredding of waste
  - Bio-culture promotion
  - Accelerated composting procedure
- **Constraints**
  - High cost

4. Debriefing session (10 min)

The facilitator leads a plenary discussion, during which the participants are prompted to reflect on the new concepts and procedures that they have learned and to ask any further questions. Also, the facilitator provides some guidelines for the experiment that the participants can conduct at their home, if they wish to do so.

5. References for activity 12

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United States Environmental Protection Agency (1998). An Analysis of Composting As an Environmental Remediation Technology. Retrieved on August 2020, from: https://www.epa.gov/sites/production/files/2015-09/documents/analpt_all.pdf

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CHAPTER 5

THE "GREEN STEAM INCUBATOR" ONLINE LIBRARY

The following section will give out some useful resources and new material, both text or video-based, to learn about the previous-mentioned subjects in depth. You can find specific scientific books and articles, as well as some general-knowledge documents, to help you through your learning journey.

1. Books

- Oshunsanya, S. O. (2018). Introductory Chapter: Relevance of Soil pH to Agriculture, In *Soil pH for Nutrient Availability and Crop Performance*. IntechOpen. Retrieved on September 16, 2020 from: https://www.intechopen.com/books/soil-ph-for-nutrient-availability-and-crop-performance/introductory-chapter-relevance-of-soil-ph-to-agriculture

  → The study of soil pH is very important in agriculture due to the fact that soil pH regulates plant nutrient.

- Yahya, A. (2020). *Emerging Technologies in Agriculture, Livestock, and Climate*. Springer.

  → This book provides applications of wireless sensor networks (WSN) in environmental monitoring, with an emphasis on livestock disease detection and agricultural management in Africa to aid farmers. This proposed system entails current and innovative monitoring technologies intended to improve agricultural conditions in Africa, with a focus on Botswana, and addresses the Internet of Things (IoT) as a set of remote monitoring protocols using WSNs to improve and ensure proper environmental maintenance.

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2. Articles

- Adoghe, A. U., Popoola, S. I., Chukwuedo, O. M., Airoboman, A. E. and Atayero, A. A. (2017). Smart Weather Station for Rural Agriculture using Meteorological Sensors and Solar Energy. *Proceedings of the World Congress on Engineering*, Vol 1. Retrieved on September 16, 2020 from: https://www.researchgate.net/publication/315822754_Smart_Weather_Station_for_Rural_Agriculture_using_Meteorological_Sensors_and_Solar_Energy

  → This document presents a cost-effective, solar-powered automated weather station.

- Frisvold, G. & Murugesan, A. (2013). Use of Weather Information for Agricultural Decision Making. *Weather, Climate, and Society*. 5 (1): 55-69. Retrieved on September 16, 2020 from: https://www.researchgate.net/publication/274491706_Use_of_Weather_Information_for_Agricultural_Decision_Making

  → This study uses data from a special subsample of the National Agricultural, Food, and Public Policy Preference Survey to assess use of weather data for agricultural decision making.

- Ravindra S. (2020, June 30). *IoT Applications in Agriculture.* IoT for All website. Retrieved on September 14, 2020 from https://www.iotforall.com/iot-applications-in-agriculture/?fbclid=IwAR06Trt-4ZLAlaeukmgGGWopfjWjkizLtiRXOlbL-VGwDVXgfyDI5wa6aVs

  → Savaram Ravindra's article introduces the reader to the contemporary understanding of agriculture, one that is connected with the Internet of Things, smart technologies and innovation. The author analyses various applications of IoT in farming and explains their benefits for the future of the sector.

- Poyen, F. B. & Kundu, P. K. and Ghosh, A. K. (2018). pH Control of Untreated Water for Irrigation. *Journal of The Institution of Engineers* (India): Series A. 99: 1-8. Retrieved on September 16, 2020 from: https://www.researchgate.net/publication/325196705_pH_Control_of_Untreated_Water_for_Irrigation

  → This document refers to the importance of pH in water and its effect on soil quality and culture.

- Schimmelpfennig, D. (2016, December 15). *Precision Agriculture Technologies and Factors Affecting Their Adoption.* United States Department of Agriculture. Retrieved on September 17, 2020 from: https://www.ers.usda.gov/amber-waves/2016/december/precision-agriculture-technologies-and-factors-affecting-their-adoption/

  → This article deals with precision agriculture technologies, which are playing an increasing role in farm production.

- Sciforce (June 22, 2020). *Smart Farming: The Future of Agriculture*. IoT for All website. Retrieved on September 16, 2020 from: https://www.iotforall.com/smart-farming-future-of-agriculture/

  → The article introduces the term "Smart farming", as an emerging concept that refers to managing farms using technologies like IoT, robotics, drones and AI to increase the quantity and quality of products while optimizing the human labor required by production. Several emerging technologies related to farming are presented.

3. Official documents

- Unit Farm Economics: DG Agriculture and Rural Development (2017). "Young farmers in the EU – structural and economic characteristics". *EU Agricultural and Farm Economics Briefs (15)*: 1-17. Retrieved on July 2, 2020 from https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agri-farm-economics-brief-15_en.pdf.

  → A brief by Unit Farm Economics of DG Agriculture and Rural Development, providing information and statistics on young farmers in the EU in comparison to various other age groups of farmers.

- United States Environmental Protection Agency (1998). *An Analysis of Composting as an Environmental Remediation Technology*. Retrieved on August 30, 2020 from: https://www.epa.gov/sites/production/files/2015-09/documents/analpt_all.pdf

  → This report summarizes the available information on the use of compost for managing hazardous waste streams (as well as other applications) and indicates possible areas for future investigations.

4. Brochures and Publications

- EIP-AGRI (2020). *EIP-AGRI Brochure- Sustainable and resilient farming: Inspiration from agro-ecology*. European Commission website. Retrieved on June 30, 2020 from https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_brochure_agro-ecology_2020_en_web.pdf.

  → A resource presenting the benefits of agro-ecological approaches on agriculture, supported by case study examples from various EU country members.

- EAFRD Projects Brochure (2012), *"Young Farmers and Younger People in Rural Europe".* European Network for Rural Development website. Retrieved on September 16, 2020 from https://enrd.ec.europa.eu/publications/eafrd-projects-brochure-young-farmers-and-younger-people-rural-europe_fr?2nd-language=cs

  → A selection of project examples showing how the European agricultural fund for rural development (EAFRD) can help to provide development opportunities for young farmers and younger people in rural Europe.

- *"Eat in Sustainia. Taste the food systems of tomorrow"* (2015). Sustania. Retrieved on September 24, 2020 from: https://issuu.com/sustainia/docs/eat_in_sustainia

  → Publication prepared by a global sustainability consulting company Sustania that provides a lot of innovative insights, inspirations and activity examples about sustainability of food systems and impact of consumption.

5. Video-based resources

- Atitlan Organics (2017, December 22). *The 12 Principles of Permaculture (Introduction).* [Video]. YouTube. https://www.youtube.com/watch?v=qUp_MdNF7sg

  → Atitlan Organics gives a brief overview of the 12 permaculture principles along with analyses of their applications.

- Vera Greutink (2016). *Grown to cook* [Channel]. YouTube. https://www.youtube.com/channel/UCidWVAWCXVVNjHXpuFCfxNA

  → Vera Greutink' YouTube channel "Grown To Cook" will help you solve any question you might have about permaculture methodologies and polyculture design.

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- Menker S. (2017). *A global food crisis may be less than a decade away* [Video]. TED Global. Retrieved on August 30, 2020 from https://www.ted.com/talks/sara_menker_a_global_food_crisis_may_be_less_than_a_decade_away?referrer=playlist-what_s_the_future_of_food

  → This talk was presented at an official TED conference. Sara Menker, the presenter, argues about the global value of agriculture.

- Baumgartner E. (2019). *Big data, small farms and a tale of two tomatoes.* TED: TEDxNatick. Retrieved on September 24, 2020 from https://www.ted.com/talks/erin_baumgartner_big_data_small_farms_and_a_tale_of_two_tomatoes

  → Erin Baumgartner is an entrepreneur that shares her experience running a farm-to-table business. She outlines how different sensors, technology and data provided by them can help to run a sustainable food and waste chain management.

6. Websites

- *Humidity and Temperature in Agriculture* (2019, May 13). OMNI Sensors & Transmitters. Retrieved on September 16, 2020 from https://sensorsandtransmitters.com/humidity-and-temperature-in-agriculture/

  → This website concerns how humidity and temperature affect agriculture.

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- Bartok Jr., J. W. (2015). *Reducing Humidity in the Greenhouse.* University of Massachusetts Amherst. Retrieved on September 16, 2020 from https://ag.umass.edu/greenhouse-floriculture/fact-sheets/reducing-humidity-in-greenhouse

  → This website from the University of Massachusetts Amherst refers to the relationship Between Temperature and Humidity.

- United Nations (UN) (n.d.) *Home.* Sustainable Development Goals. Retrieved September 09, 2020 from https://www.un.org/sustainabledevelopment/

  → A website that provides resources and educational materials about the Sustainable Development Agenda. All goals are important but the one that have interest for the Green STEM project are:
    - ✓ Goal 2: Zero hunger
    - ✓ Goal 6: Ensure access to water and sanitation for all
    - ✓ Goal 12: Responsible consumption and production
    - ✓ Goal 15: Life on land

- European Comission (n.d.). *Local Action Group Database.* European Network for Rural Development website. Retrieved on September 09, 2020 from: https://enrd.ec.europa.eu/leader-clld/lag-database_en?2nd-language=cs

  → This database allows to get in touch with the Local Action Groups, so as to network and cooperate with each other. The database has over 3000 groups.

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