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Sustainable development in the EU: eco-friendly practices in innovation and technologies

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SUSTAINABLE DEVELOPMENT IN THE EU: ECO-FRIENDLY PRACTICES IN INNOVATION AND TECHNOLOGIES

Alina Nicuta

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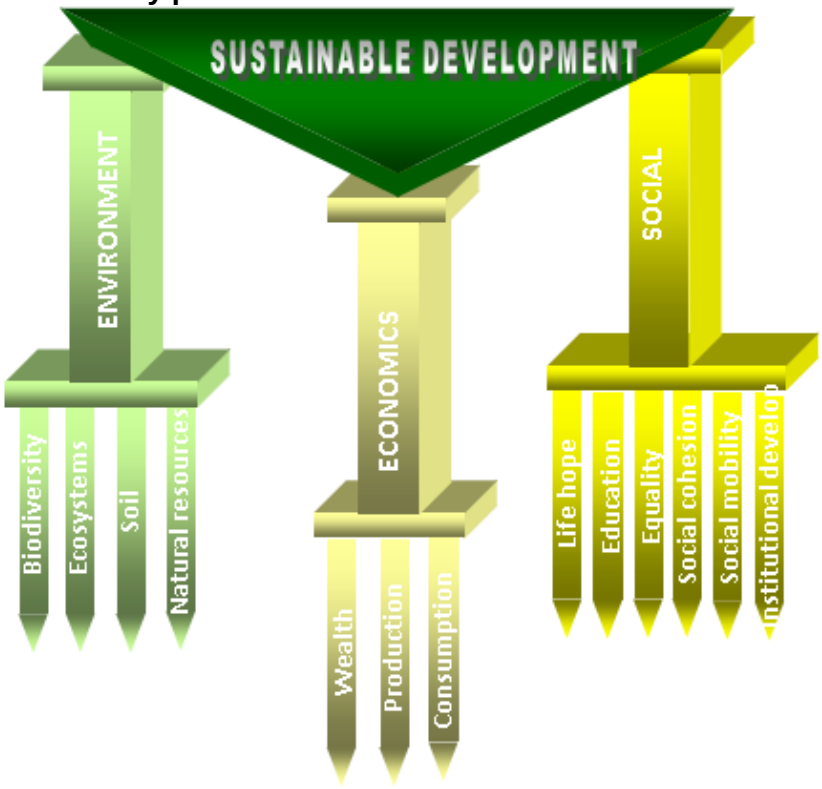
1. Sustainability concept

Starting from the 60's, when two publications, "*Silent Spring*" (Carson, 1962) and "*The Economics of the Coming Spaceship Earth*" (Boulding, 1966) raised some questions on the interdependence between economics and ecology, followed by the 70's with the "*Limits to Growth*" report (Meadows et al., 1972), a new concept was brought to life: "sustainable". This term became shortly a "buzzword", embraced by all areas of activity, so that currently the literature contains a significant number of definitions, theories, interpretations, statistics and documents on the matter.

Figure 1: Sustainability pillars



The fundamental idea on the concept and which must be taken into consideration is that the process of sustainability or sustainable development is supported by three key pillars: economics, environment and social. Some researchers like Jon Hawkes in his book "The Forth Pillar of Sustainability. Culture's essential role in public planning" debate on the introduction of a forth element, the "culture", related to national cultural identity, cultural pluralism, geoculture, etc. Figure 1 below details the components integrated by each of the three sustainability pillars.

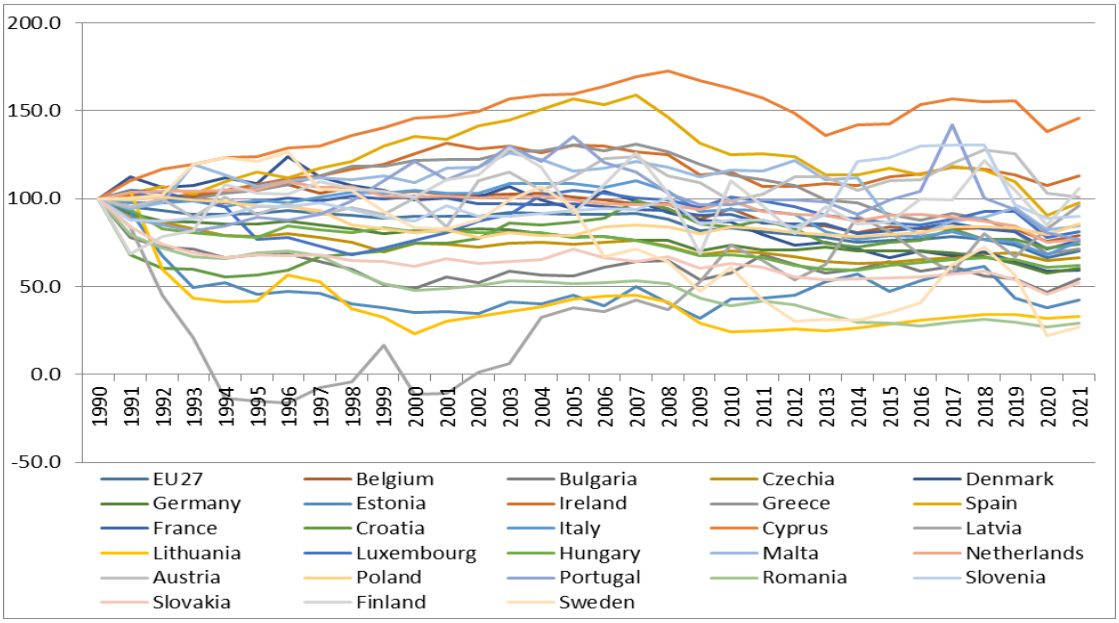
2. European overview on sustainability

European Union (EU) grants a significant importance to the environmental issue, so that all member countries must implement joint policies and associated measures. Annually are made statistics on the pollutant factors in order to see the results of policy implementation. In the following, some information on different sustainability actions is exposed.

The first set of statistics presents the net greenhouse gas emissions[1] for EU27 (average) and for each member country (Graph 1). Among EU countries, Romania positions as a medium to low net GHG emissions one, with a steady but clear reduction in time (from 79.3% in 1991 to 29% in 2021, where index 1990=100). In comparison, there are countries like Latvia that, after a sharp decrease of emissions, starting with 2004, the year of its integration in the EU, it increased again the polluting activities (in 2021, the value was of 96.2%, more than the level from 1991 of 83.9%).

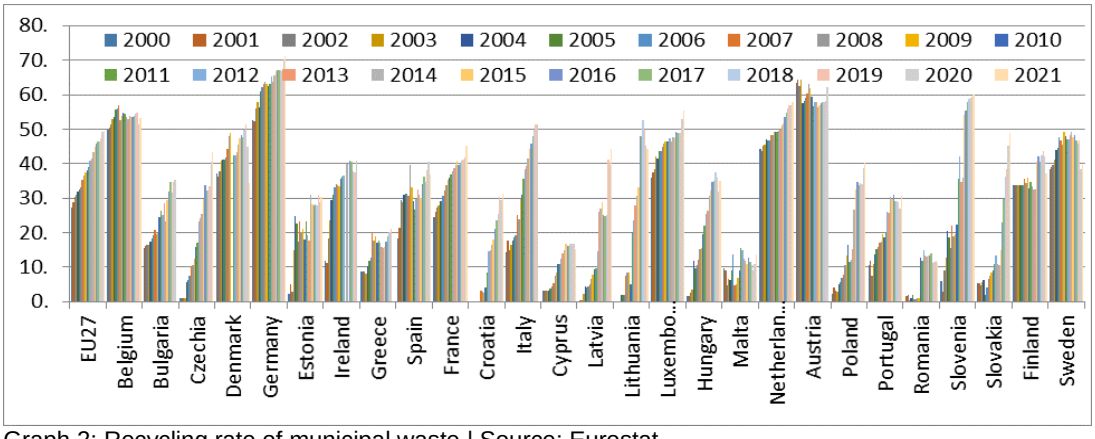
Our neighbour country, Bulgaria, reduced the emissions since 1990, but it has almost twice the value of Romania's emissions. High values, above the 100 threshold, in 2021, are in the case of Cyprus, Ireland, Finland and Austria. Spain has maintained fairly high values of the net greenhouse gas emissions with a maximum of 159.2% in 2007, in 2021 reaching 97.7%. The 2030 EU target for net greenhouse gas emissions reduction is 55% below 1990 level, and in 2020 it was achieved a 34% value compared to 1990 reference point (EEA, 2022).

[1] According to European Environment Agency (EEA) and Eurostat, the net greenhouse gas emissions refer to "total national emissions of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen triflouride (NF3) and sulphur hexafluoride (SF6) from all sectors of the GHG emission inventories (including international aviation and indirect CO2)".



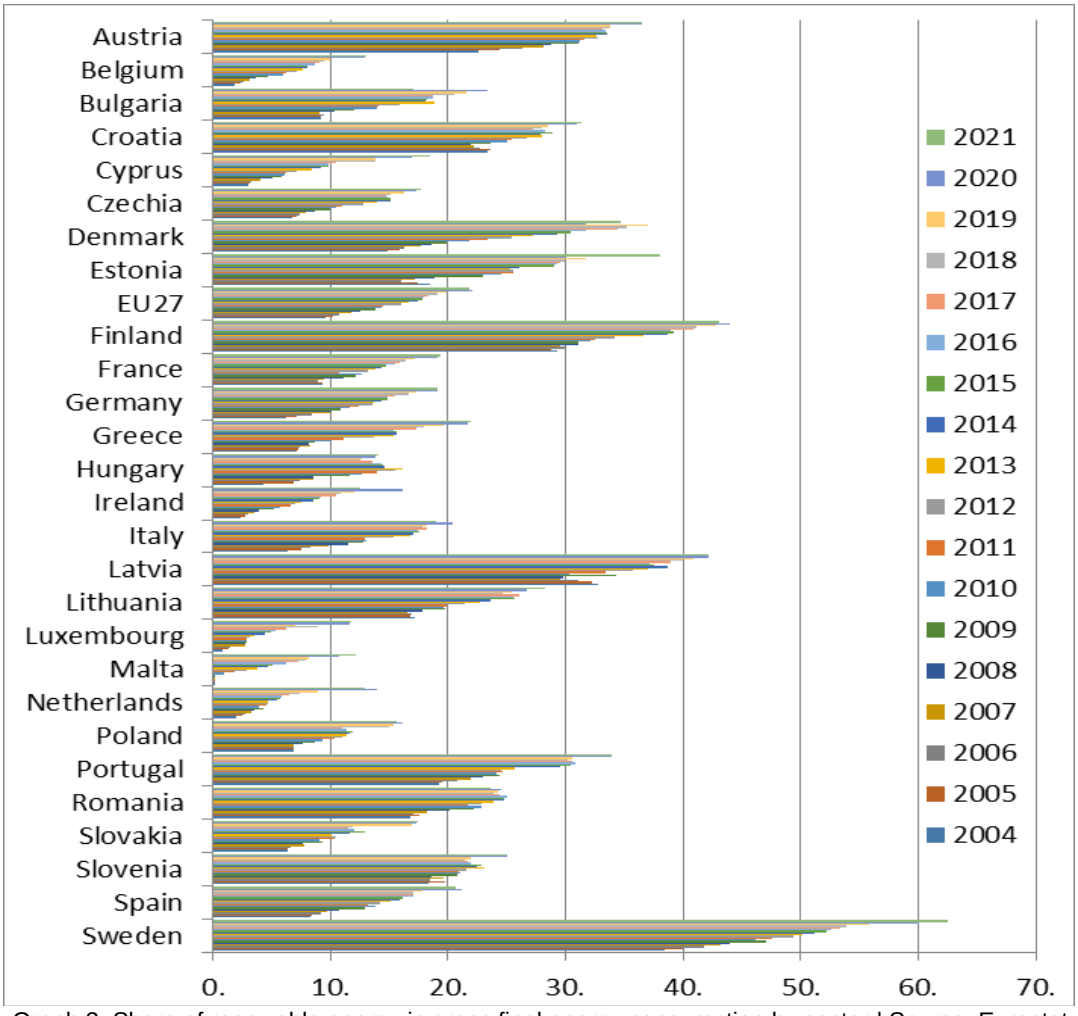
Graph 1: Net greenhouse gas emissions | Source: European Environment Agency (EEA)

Second graph presents statistics on the recycling rate of municipal waste, calculated as an annual percent for 27 EU member countries. As can be observed from the graph, Germany and Austria are leaders in the recycling sector, but what atracts the attention is the efficacy in time of Slovenia's recycling policy.



Graph 2: Recycling rate of municipal waste | Source: Eurostat

Third graph details on the share of renewable energy in gross final energy consumption by sector for the same number of 27 EU member countries, expressed as annual percentage value. It is highlighted that Finland registers the best values, followed, in the last years, by Latvia and Austria. Romania registers values above the EU's average, while Bulgaria registered its best value in 2020, but lower than our country.



Graph 3: Share of renewable energy in gross final energy consumption by sector | Source: Eurostat

3 Romania overview on sustainability practices

3.1 SDG approach in Romania

European Union policy associated with the concept of *sustainable development* is to increase the awareness on its importance and applicability (the so-called ”put into practice” component. The technical sector creates a connection bridge between theory and practice in the area of sustainable development.

The concepts, policies and theories are used to make decisions in accordance with European practices on sustainable development. In 2015, at international level, it was established 2030 Agenda for Sustainable Development, which details on a number of 17 Sustainable Development Goals (SDG). Since the adoption of the 2030 Agenda, EU has made progress across a large majority of the SDGs. Following the international trend, Romania also integrated the “sustainability” concept into its practices in all areas of development. This can be observed in the following statistics that present Romania’s position on several SDG, like *SDG 6: Clear water and sanitation, SDG 7: Affordable and clean energy, SDG 11: Sustainable cities and communities, SDG 13: Climate action.*

As observed in table 1, there is a comparison between statistical values registered for Romania and European Union, some sectors registering significant differences, and others, only slightly. Romania must implement measures and take action on the areas where there are registered the highest differences as compared to EU average (e.g., in the case of SDG 6, the highest differences are for “Water quality”, for SDG 7 would be the “Energy supply”, in case of SDG 11 can be mentioned the “Adverse environmental impact”; as for SDG 13 is the “Financing of climate action”).

Romania’s performance across four SDG (Clear water and sanitation, Affordable and clean energy, Sustainable cities and communities and Climate action) is presented below.

Table 1: SDG for Romania | Source: Eurostat, EU SDG indicators, 2023

SDG / Sub-theme	INDICATOR	UNIT	ROMANIA				EUROPEAN UNION			
			Starting		Latest		Starting		Latest	
			year	value	year	value	year	value	year	value
SDG 6 – Clean water and sanitation										
Sanitation	Population having neither a bath, nor a shower, nor indoor flushing toilet in their household	% of population	2015	30.5	2020	21.2	2015	2.2	2020	1.5
	Population connected to at least secondary wastewater treatment	% of population	2015	39.7	2020	51.8	2015	78.9	2020	81.1
Water quality	Biochemical oxygen demand in rivers	mg O_2 per litre	2015	3.97	2020	3.43	2015	3.04	2020	2.65
	Nitrate in groundwater (four-year moving average)	mg NO_3 per litre	N/A	:	N/A	:	2015	23.3	2020	22.6
	Phosphate in rivers	mg PO_4 per litre	2015	0.105	2020	0.107	2015	0.058	2020	0.072
	Inland water bathing sites with excellent water quality	% of bathing sites with excellent water quality	2019	0.0	2021	0.0	2016	82.1	2021	78.2
Water scarcity	Water exploitation index (WEI+)	% of renewable water resources	2014	25.2	2019	9.0	2014	3.8	2019	3.6
SDG 7 – Affordable and clean energy										
Energy consumption	Primary energy consumption	tonnes of oil equivalent per capita	2016	1.6	2021	1.7	2016	3.1	2021	2.9
	Final energy consumption	tonnes of oil equivalent per capita	2016	1.1	2021	1.3	2016	2.2	2021	2.2
	Final energy consumption in households per capita	kgoe	2016	376	2021	458	2016	564	2021	586
	Energy productivity	EUR per kgoe	2016	4.8	2021	5.4	2016	7.8	2021	8.5
Energy supply	Share of renewable energy in gross final energy consumption	%	2016	25.0	2021	23.6	2016	18.0	2021	21.8
	Energy import dependency	% of imports in gross available energy	2016	21.9	2021	31.6	2016	56.2	2021	55.5
Access to affordable energy	Population unable to keep home adequately warm	% of population	2016	13.8	2021	10.1	2016	9.0	2021	6.9
SDG 11 – Sustainable cities and communities										
Quality of life in cities and communities	Severe housing deprivation rate	% of population	2015	19.8	2020	14.3	2015	5.3	2020	4.3
	Population living in households suffering from noise	% of population	2015	22.2	2020	16.1	2015	18.3	2020	17.6
	Premature deaths due to exposure to fine particulate matter ($PM_{2.5}$)	number per 100 000 persons	2015	121	2020	112	2015	73	2020	54
	Population reporting crime, violence or vandalism in their area	% of population	2015	13.1	2020	8.8	2015	13.2	2020	10.7
Sustainable mobility	Road traffic deaths	number per 100 000 persons	2016	9.7	2021	9.3	2016	5.3	2021	4.5
	Share of buses and trains in total passenger transport	% of total inland passenger-km	2015	22.1	2020	18.1	2015	17.6	2020	12.8
Adverse environmental impacts	Settlement area per capita	m^2	2015	364.8	2018	528.4	2015	680.6	2018	703.4
	Recycling rate of municipal waste	% of total municipal waste generated	2016	13.4	2021	11.3	2016	45.9	2021	49.6
	Population connected to at least secondary wastewater treatment	% of population	2015	39.7	2020	51.8	2015	78.9	2020	81.1
SDG 13 – Climate action										
Climate mitigation	Net greenhouse gas emissions	tonnes per capita	2016	4.0	2021	4.3	2016	8.2	2021	7.4
	Net greenhouse gas emissions from land use and forestry (LULUCF sector)	tonnes CO_2 eq. per km²	2016	-146.4	2021	-137.2	2016	-70.3	2021	-50.1
	Share of renewable energy in gross final energy consumption	%	2016	25.0	2021	23.6	2016	18.0	2021	21.8
	Average CO_2 emissions per km from new passenger cars	g CO_2 per km	2016	122.0	2021	126.5	2016	117.6	2021	116.3
Climate impacts and adaptation	Climate-related economic losses (30-year moving average)	EUR per inhabitant	2016	23.8	2021	24.9	2016	27.1	2021	33.9
	Population covered by the Covenant of Mayors for Climate and Energy signatories	% of population	2017	38.3	2022	33.9	2017	40.1	2022	44.3
Financing climate action	Contribution to the international USD 100bn commitment on climate-related expenditure	EUR million, current prices	2016	1	2021	5	2016	19,016	2021	23,043

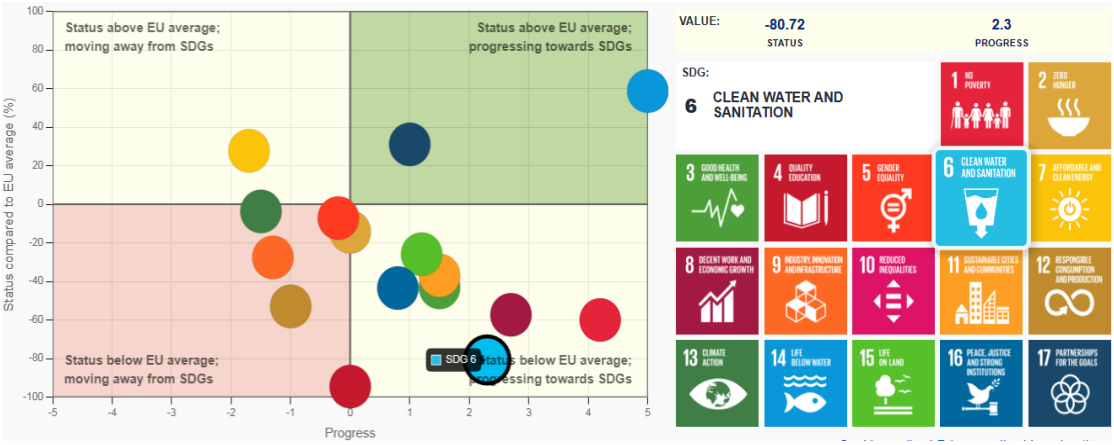


Figure 4: **SDG 6: Clear water and sanitation – ROMANIA |** Source: Eurostat

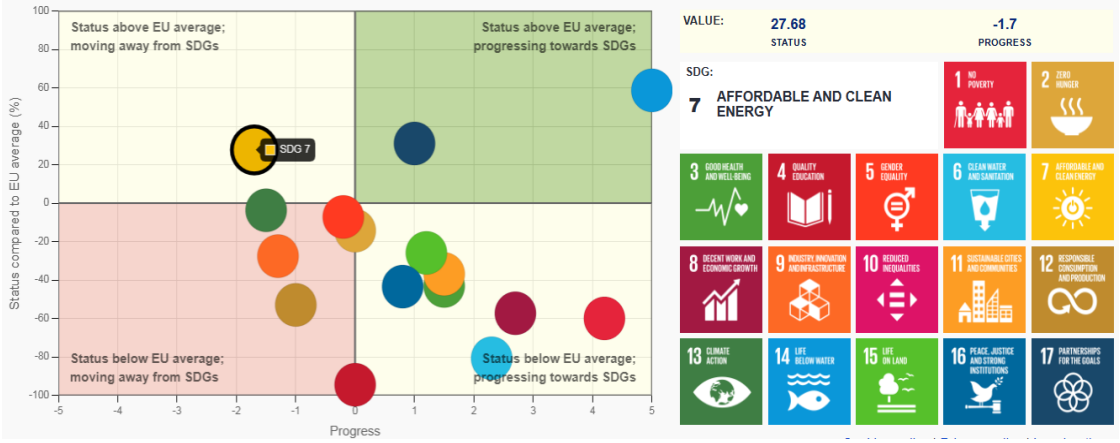


Figure 2: **SDG 7: Affordable and clean energy – ROMANIA |** Source: Eurostat

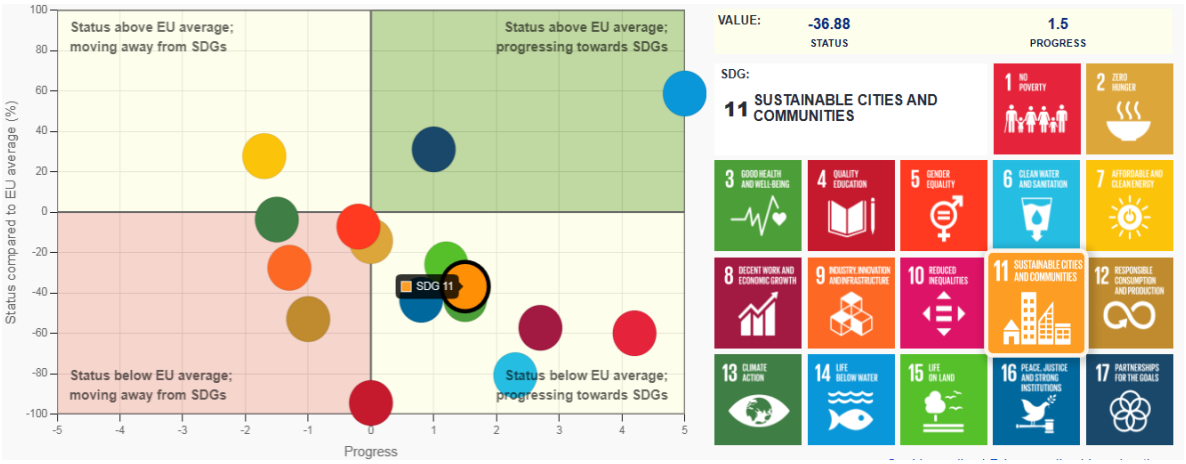


Figure 5: **SDG 11: Sustainable cities and communities – ROMANIA |** Source: Eurostat

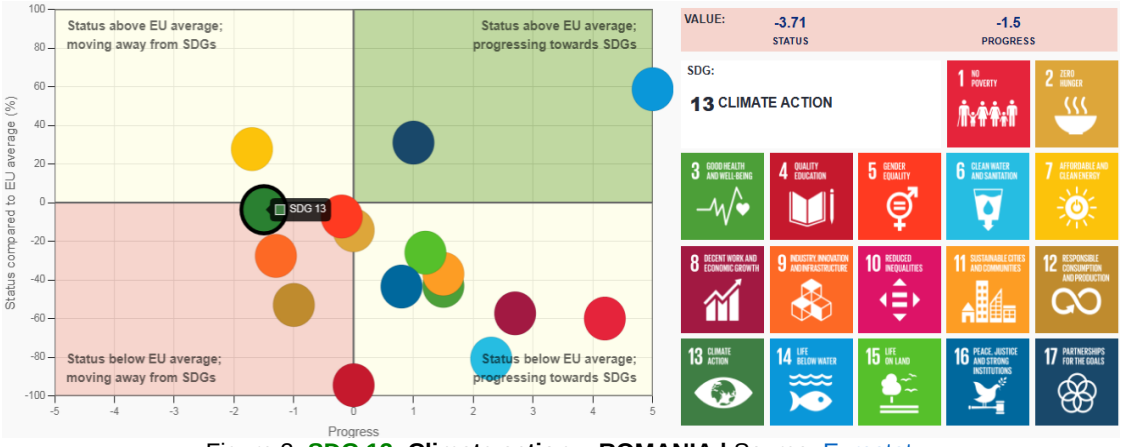


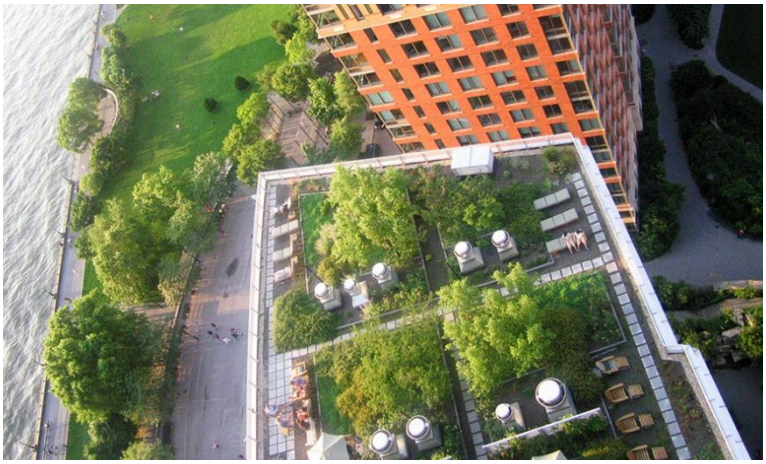
Figure 3: **SDG 13: Climate action – ROMANIA |** Source: Eurostat

3.1. *Eco-friendly practices in construction sector*

According to UN statistics, more than half of world population lives in urban areas. This situation implies an emergency need to identify solutions for a sustainable performance of the buildings we live and work in. Construction sector has the capacity to bring a major contribution to a sustainable future. In the publication ”Sound of Green: Designing for Sustainability in Buildings” (State of Green, 2023) it is mentioned that “*buildings incorporate more than 40% of the energy consumption during their lifetime”*.

Talking about sustainable constructions means providing long-term viability by referring to a wide diversity of topics, like: sustainable design and ecologic building management, performant materials, energy efficiency in construction, operation and maintenance, long term monitoring, etic standards, eco-friendly technology and products, innovative financial models, current conditions improvement, interdependence between environment, infrastructure and urban architecture; flexibility in constructions usage, functioning and change; knowledge dissemination; development and innovation in new and composite materials, nanomaterials, recycling old materials by their incorporation in new products and so on. Just one question: what better way to expose the put into practice of *sustainability* concept than presenting one segment of sustainable development application in constructions by including the "green roofs"?. This constructive component consists of vegetation surfaces on buildings roofs. It is present for centuries, mainly on the houses from North and West of Europe. In 20th century, the innovations in design and concerns for environmental impact of buildings lead to a legal request for green roofs in several European countries.

According to the statistics made in January 2023 on Green-roofs market (TechnavioPlus, 2023), it was identified an increase estimated at ***12.18%*** *between 2022 and 2027, representing a value of* ***USD 8,106.69 million***. The growth of the market depends on several factors, including a reduction in global warming due to green roofs, better management of rainwater runoff flow, and supporting policies. Moreover, according to Building Radar (2023) and European Federation of Green Roof & Wall Associations, *Germany has the greatest share of green roofs within Europe*. The industry benefited from government policies, since this type of construction element is considered as providing beneficial services for the local community. After becoming so popular in EU, "green roofs" arrived in USA, being considered as a durable and attractive solution for commercial buildings.



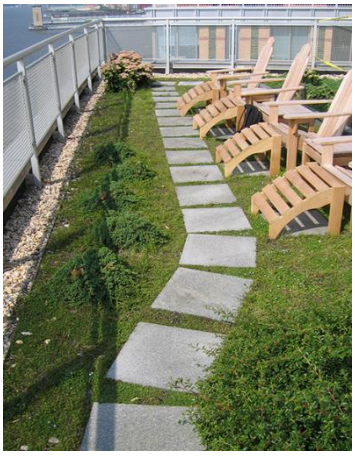


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Figure 6: The Solaire, NYC, is the first green residential building in the U.S. | Source: The Solaire (2003),

Figure 7: Moesgaard Museum, Højbjerg, Denmark | Source

Green roofs gained lately significant popularity in the area of design as a sustainable and aesthetical urban solution. Their structural system is a combination between a waterproofing roof over which is applied another layer that can support, partially or in total, a natural environment made of plants. This type of roofs is specially designed to be autonomous and easy to maintain, providing a roof system that is adapted to our days, when people became more interested in environment protection and improvement of air quality.

Figure 8: Fukuoka Prefectural International Hall of Japan | Source

The “green roof” can also be found under the name of “ecologic roof” or “garden roof”, and represents in fact a stratified roof, which is capable to raise plants on its flat or slightly sloped waterproof substrate. In comparison with traditional roof systems, green roofs have a longer life expectancy, they reduce the energy costs due to natural insulation, improve the air quality and absorb rainwater. These types of roofs can be divided into two general categories: intensive and extensive (Building Radar, 2023). In between these two generic types, there are several ecologic solutions, including semi-intensive and semi-extensive.

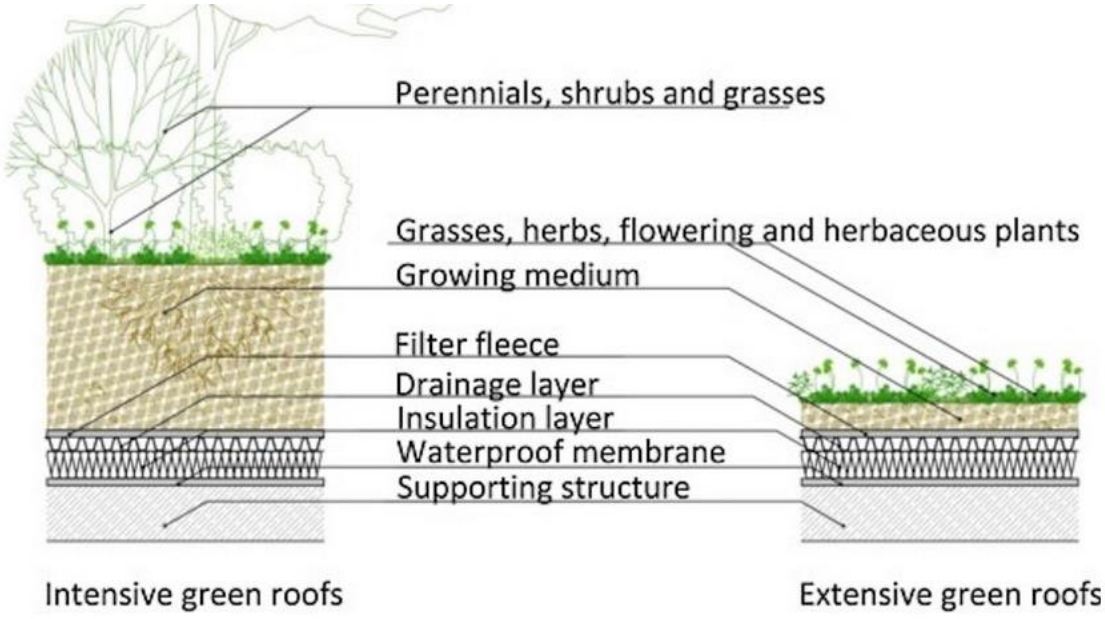


Figure 9: Types of green roofs | Source

Intensive green roofs have a deep growth environment, which allows the use of trees and bushes. Several parks are actually, intensive green roofs, like parks from Wharf Estate Canary in Canada Square and Westferry Circus, but also the roof of Cannon Street Station from London. The depth of growth environment increases the request for the construction structure strength and implies a complex irrigation system for maintenance. Shortly, intensive roofs are highly costly and imply a complementary structural design of the building.

Figure 10: Canary Wharf Residential | Source

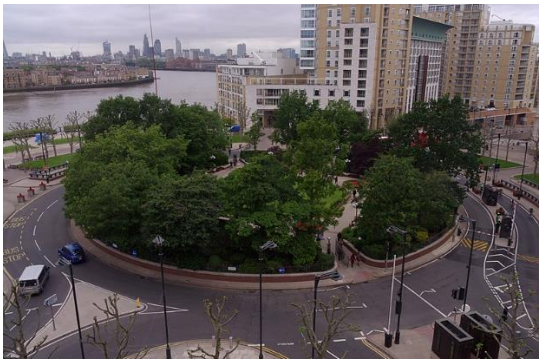


Figure 11: Westferry Circus | Source

Figure 12: Cannon Rail Station, London | Source: John Gaffen, Alamy Stock Photo

Extensive green roofs have a reduced growth environment, they imply a minimal maintenance and in general they don't require an irrigation system. Generally, are less costly than intensive green roofs.

Figure 13: Nanyang Technological University, Singapore | Source: 15 Interesting Green Roofs From Around the World,

Figure 14: Restaurant from Porumbacu de Sus village, close to Sibiu City, Romania | Source: https://valeazanelor.ro

An interesting example of combined intensive and extensive green roof can be found on a building from Milano, Italy. This construction is famous for the vegetation planted on the exterior of the building, in each apartment. Due to its looks, the construction is named "Bosco Verticale" or Vertical Forest. A detailed presentation of the project can be seen at the following link

Figure 15: Building in Milano, named "Bosco Verticale" | Source

In the "Living Roofs and Walls. Technical Report: Supporting London Plan Policy" (Greater London Authority City Hall, 2008) can be found useful information on these types of structures, but most important on the financial implications of such an investment. According to the same source, green roofs costs are known for their difficult evaluation, due to the fact that there exists a significant number of factors that modify the price per square meter. Among these factors can be mentioned (Greater London Authority City Hall, 2008):

- *Roof size*. Small roofs can be very expensive. Such an example can be a small roof from London centre that costed 185£/square meter. As the constructive area increases, the price per square meter reduces;
- *Roof weight*. This aspect will modify the price as related to the lifting costs of the elements to the roof level;
- *Green roof type requested*. As related to the extension of the green roof, an instant green will imply the use of sedum mats plants that are more expensive than sedum plug plats. The cheapest option is usually the hydro sowing, but will last some time until the plant will reach the desired green effect. The roofs conceived for biodiversity might as well be cheaper if will be sowed with a mix of right plants or allowing them to develop by their own vegetal process;
- *Initial maintenance and installation costs*. Although sedum plug plants can be less expensive per square meter, will be a cost regarding the roof stability in the first two years regarding irrigation and weeding;
- *Waterproofing and isolation type used*. Different waterproofing systems ask for different applications, additional to different work force costs;

- *Producers and contractors involvement*. Quite often green roofs are inaccurate as price, their builders don't give detailed plans from the very beginning but only when the roof has already been conceived;
- *Installation methods*. Usually, it is necessary that the installation to be monitored in order to provide the specific concept and to follow the necessary specifications (especially in the case of roofs conceived for biodiversity).

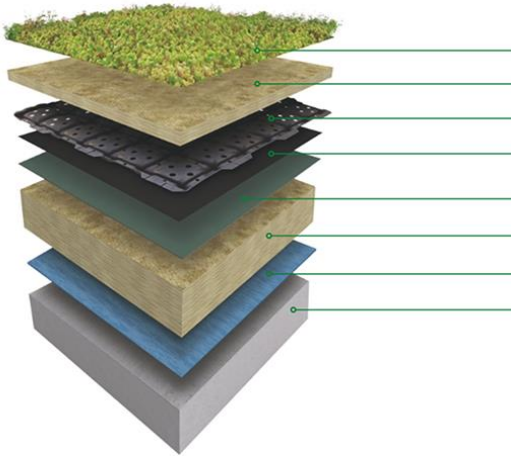
According to the article "Advantages and Disadvantages of Green Roofs", on the Green Roofers website, the green roofs provide a significant number of benefits to the environment, which compensate for the initial costs:

- Provide thermal insulation which saved energy costs and reduces the production of CO2. In general, the plants from green roof activity reduces the quantity of CO2 from the atmosphere;
- Contribute to ozone reduction production by decreasing the global warming effect and by absorption of air particles;
- Create barriers against noises and provide sound insulation for buildings positioned below airplane routes or close to airports;
- Provide the habitat for a valuable wild fauna in the big cities and can help in the realisation, at local and regional level of biodiversity objectives;
- Create an environment of physic and mental relaxation;
- Significantly reduce rain runoff from buildings.
- Bring biodiversity benefits more than traditional roofs.

If not man made, the nature itself gives us examples of green roofs as can be observed in figure 16 below.

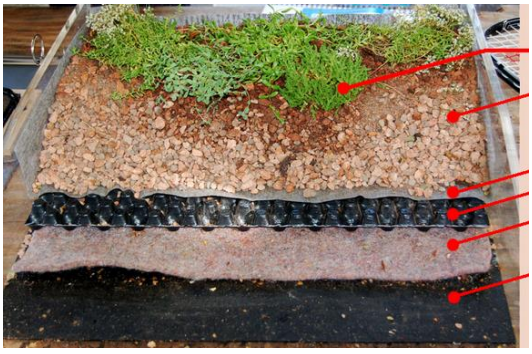
Figure 16: Architecture Durable (21) | Source

In order to better understand the construction process of a green roof, it is important to know which are the main layers found in the green roof structure. For a detailed presentation of the constructive process, the Youtube link can be consulted.
Urbanscape green roof is a complex system, with reduced weight, composed of an anti-root membrane, a drainage system, an unique substrate patented based on basaltic mineral cotton and vegetation layer.



Vegetation
Urbanshape sublayer
Drainage
Anti-root membrane
Waterproofing membrane
Insulation
Vapor barrier
Roof structure

Figure 17: Green roof system (22) | Source



Fatty herbs mix
Vegetal sublayer

Filter film
PVC modulation layer
Geotextile film
Bituminous net

Figure 18: Green roof layers | Source

4. Recommendations

- Sustainability as key development concept was adopted by all areas of activity. What interests mostly is the applicability of the sustainability principles. In this context, the technical sector creates a connection bridge between theory and practice in the area of sustainable development;
- European Union grants a significant importance to the environmental issue, so that all member countries must implement joint policies and associated measures;
- Sustainability 2030 Agenda details on a number of 17 Sustainable Development Goals (SDG). Since its adoption, EU made progress across a large majority of the SDGs. Following the international trend, Romania also integrated the "sustainability" concept into its practices in all areas of development.
- Construction of green roofs is positioned on an increasing trend in urban architecture since the process has significant benefits, mainly because they improve life quality by reducing air pollution. The roofs system is composed by a wide diversity of plants. In short, green roofs are well worth considering when planning for a building.

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PROJECT NUMBER – 621262-EPP-1-2020-1-RO-EPPJMO

The reasons laying behind the project are related to the harsh economic challenges the EU is currently facing, the youth being mostly affected by very high unemployment rates. Thus, encouraging academic debate on how can young population acquire more competences and ease their labour market integration may be the key for reviving European economy (a more resilient EU).

All activities proposed in the project have an interdisciplinary and multidisciplinary character: the events are aimed at specialists in various EU issues (regional development, health, European funding opportunities, methodological aspects); the target audience consists of students, teachers, researchers, broad public – having different profiles and professional backgrounds; the topics of the events organised (seminars, workshops, round tables) cover many perspectives: economic, social, political, medicine, engineering etc.

EURES project is coordinated by Ramona Tiganasu, researcher at Centre for European Studies

The Centre for European Studies (CES) is an interdisciplnary department within the Faculty of Law from Alexandru Ioan Cuza University of Iasi, Romania and operates as a Jean Monnet Centre of Excellence in European Studies, from 2009.

CES's mission is to contribute to the development of the European dimension of education, to promote research and consultancy, information, documentation in the area of European studies and to, directly and indirectly, support the process of economic and social development in the North-East region of Romania.

The main goal is to contribute to a better knowledge and understanding of the process of integration, in its different aspects, of the standards for Romania's participation in this process and of the place and role of the European Union in the world. In this goal we develop education, training and research programmes, organise different scientific events. As major fields of interest, the institution is focused on European economy, European policies, internal market, trade, interregional and trans-border cooperation etc

EURES POLICY BRIEF

SUSTAINABLE DEVELOPMENT IN THE EU: ECO-FRIENDLY PRACTICES IN INNOVATION AND TECHNOLOGIES

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CENTRE FOR EUROPEAN STUDIES FACULTY OF LAW

Jean Monnet Module on EU Interdisciplinary Studies: Widening Knowledge for a more Resilient Union

PROJECT NUMBER 621262-EPP-1-2020-1-RO-EPPJMO-MODULE

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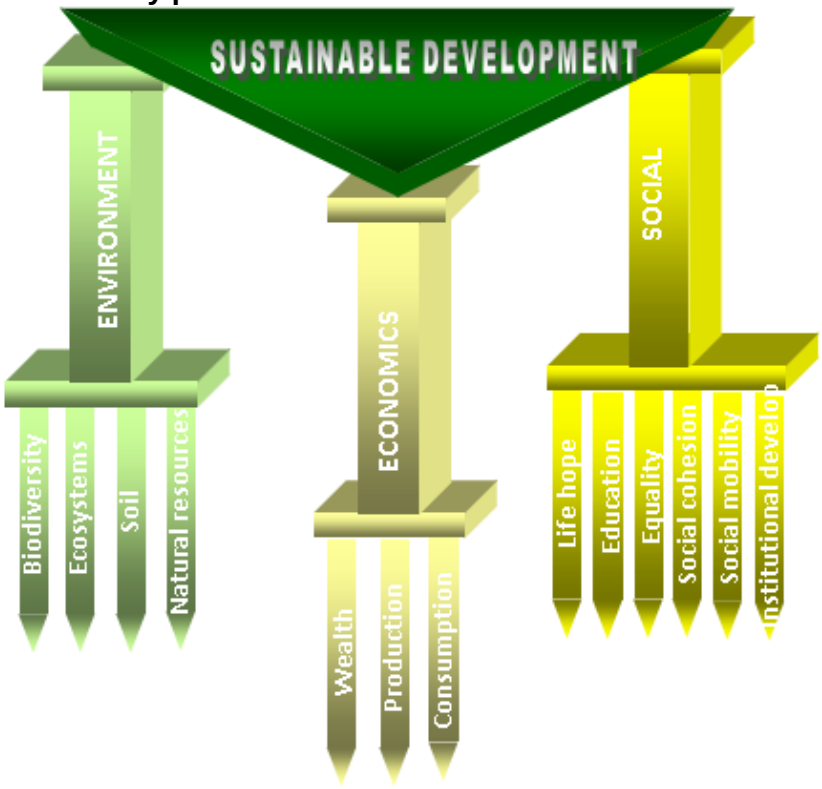
1. Sustainability concept

Starting from the 60's, when two publications, "*Silent Spring*" (Carson, 1962) and "*The Economics of the Coming Spaceship Earth*" (Boulding, 1966) raised some questions on the interdependence between economics and ecology, followed by the 70's with the "*Limits to Growth*" report (Meadows et al., 1972), a new concept was brought to life: "sustainable". This term became shortly a "buzzword", embraced by all areas of activity, so that currently the literature contains a significant number of definitions, theories, interpretations, statistics and documents on the matter.

Figure 1: Sustainability pillars



The fundamental idea on the concept and which must be taken into consideration is that the process of sustainability or sustainable development is supported by three key pillars: economics, environment and social. Some researchers like Jon Hawkes in his book "The Forth Pillar of Sustainability. Culture's essential role in public planning" debate on the introduction of a forth element, the "culture", related to national cultural identity, cultural pluralism, geoculture, etc. Figure 1 below details the components integrated by each of the three sustainability pillars.

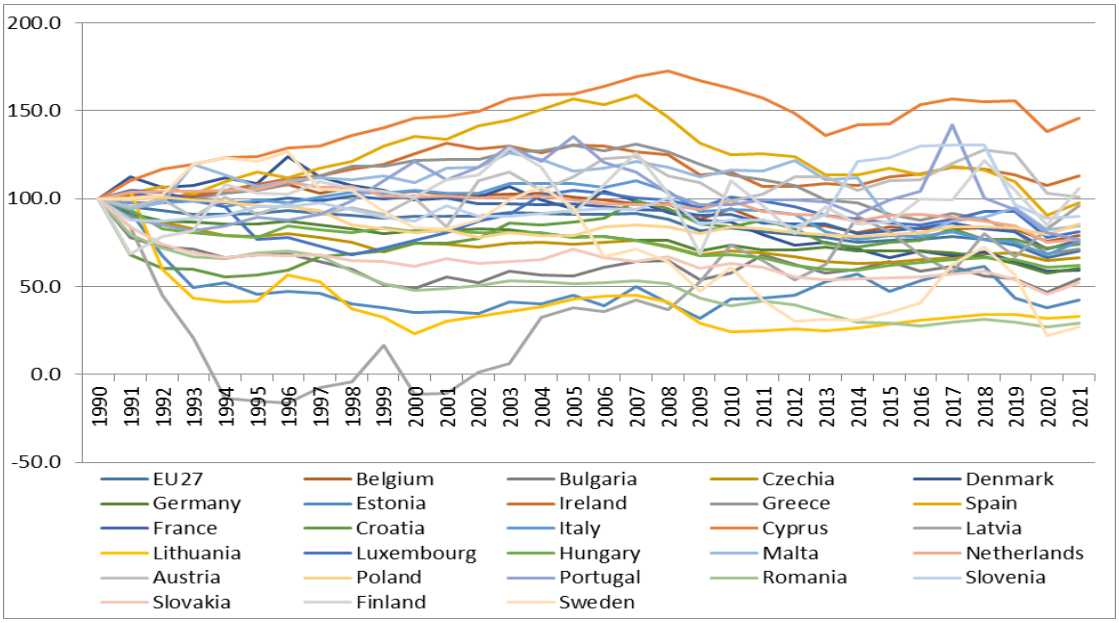
2. European overview on sustainability

European Union (EU) grants a significant importance to the environmental issue, so that all member countries must implement joint policies and associated measures. Annually are made statistics on the pollutant factors in order to see the results of policy implementation. In the following, some information on different sustainability actions is exposed.

The first set of statistics presents the net greenhouse gas emissions[1] for EU27 (average) and for each member country (Graph 1). Among EU countries, Romania positions as a medium to low net GHG emissions one, with a steady but clear reduction in time (from 79.3% in 1991 to 29% in 2021, where index 1990=100). In comparison, there are countries like Latvia that, after a sharp decrease of emissions, starting with 2004, the year of its integration in the EU, it increased again the polluting activities (in 2021, the value was of 96.2%, more than the level from 1991 of 83.9%).

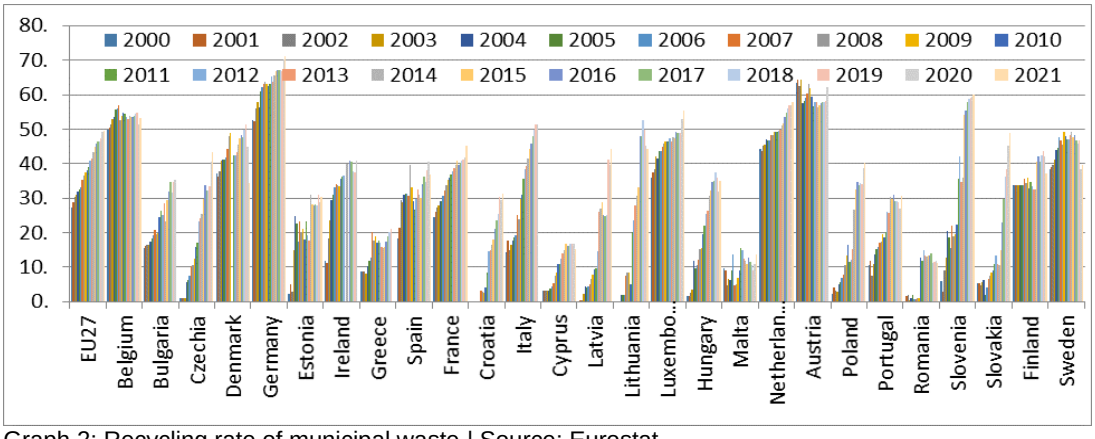
Our neighbour country, Bulgaria, reduced the emissions since 1990, but it has almost twice the value of Romania's emissions. High values, above the 100 threshold, in 2021, are in the case of Cyprus, Ireland, Finland and Austria. Spain has maintained fairly high values of the net greenhouse gas emissions with a maximum of 159.2% in 2007, in 2021 reaching 97.7%. The 2030 EU target for net greenhouse gas emissions reduction is 55% below 1990 level, and in 2020 it was achieved a 34% value compared to 1990 reference point (EEA, 2022).

[1] According to European Environment Agency (EEA) and Eurostat, the net greenhouse gas emissions refer to "total national emissions of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen triflouride (NF3) and sulphur hexafluoride (SF6) from all sectors of the GHG emission inventories (including international aviation and indirect CO2)".



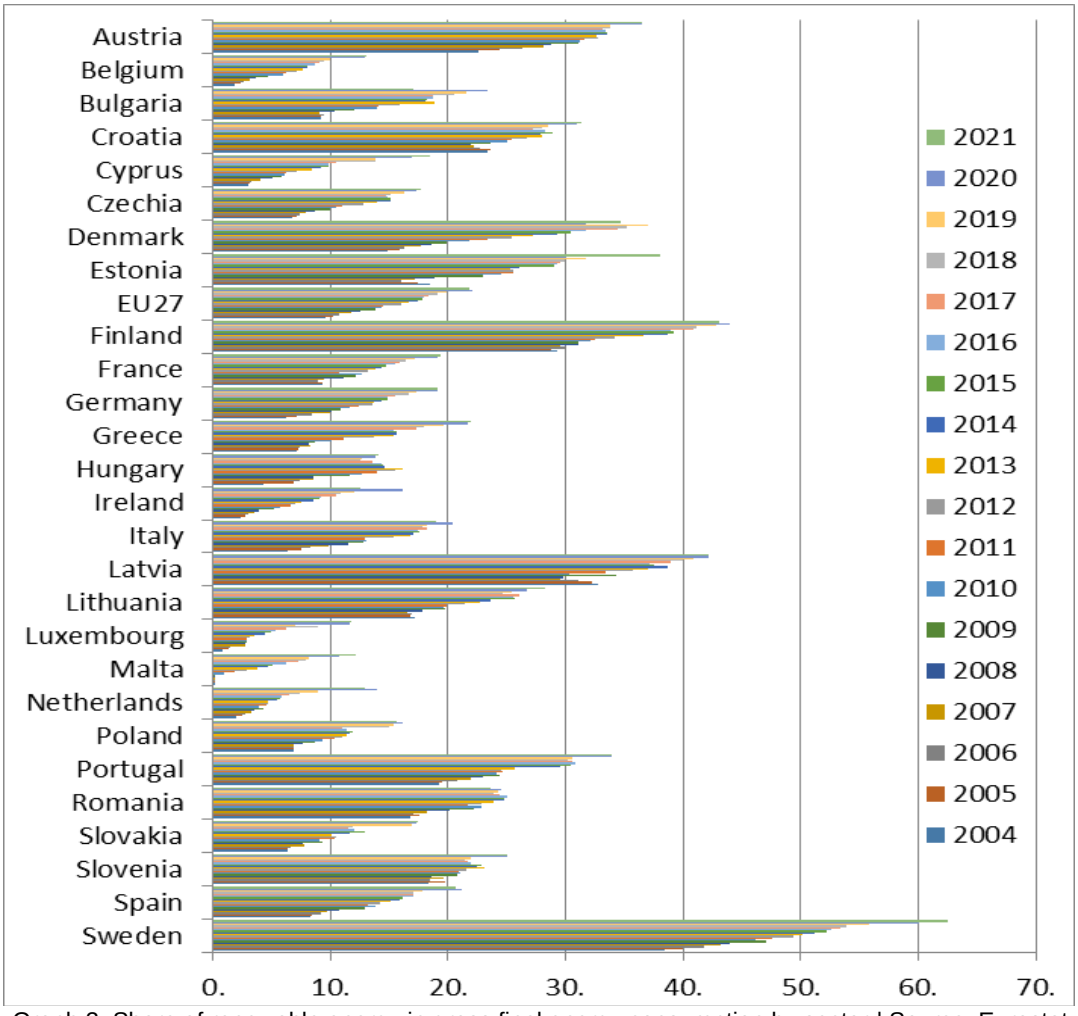
Graph 1: Net greenhouse gas emissions | Source: European Environment Agency (EEA)

Second graph presents statistics on the recycling rate of municipal waste, calculated as an annual percent for 27 EU member countries. As can be observed from the graph, Germany and Austria are leaders in the recycling sector, but what atracts the attention is the efficacy in time of Slovenia's recycling policy.



Graph 2: Recycling rate of municipal waste | Source: Eurostat

Third graph details on the share of renewable energy in gross final energy consumption by sector for the same number of 27 EU member countries, expressed as annual percentage value. It is highlighted that Finland registers the best values, followed, in the last years, by Latvia and Austria. Romania registers values above the EU's average, while Bulgaria registered its best value in 2020, but lower than our country.



Graph 3: Share of renewable energy in gross final energy consumption by sector | Source: Eurostat

3 Romania overview on sustainability practices

3.1 SDG approach in Romania

European Union policy associated with the concept of *sustainable development* is to increase the awareness on its importance and applicability (the so-called ”put into practice” component. The technical sector creates a connection bridge between theory and practice in the area of sustainable development.

The concepts, policies and theories are used to make decisions in accordance with European practices on sustainable development. In 2015, at international level, it was established 2030 Agenda for Sustainable Development, which details on a number of 17 Sustainable Development Goals (SDG). Since the adoption of the 2030 Agenda, EU has made progress across a large majority of the SDGs. Following the international trend, Romania also integrated the “sustainability” concept into its practices in all areas of development. This can be observed in the following statistics that present Romania’s position on several SDG, like *SDG 6: Clear water and sanitation, SDG 7: Affordable and clean energy, SDG 11: Sustainable cities and communities, SDG 13: Climate action.*

As observed in table 1, there is a comparison between statistical values registered for Romania and European Union, some sectors registering significant differences, and others, only slightly. Romania must implement measures and take action on the areas where there are registered the highest differences as compared to EU average (e.g., in the case of SDG 6, the highest differences are for “Water quality”, for SDG 7 would be the “Energy supply”, in case of SDG 11 can be mentioned the “Adverse environmental impact”; as for SDG 13 is the “Financing of climate action”).

Romania’s performance across four SDG (Clear water and sanitation, Affordable and clean energy, Sustainable cities and communities and Climate action) is presented below.

Table 1: SDG for Romania | Source: Eurostat, EU SDG indicators, 2023

SDG / Sub-theme	INDICATOR	UNIT	ROMANIA				EUROPEAN UNION			
			Starting		Latest		Starting		Latest	
			year	value	year	value	year	value	year	value
SDG 6 – Clean water and sanitation										
Sanitation	Population having neither a bath, nor a shower, nor indoor flushing toilet in their household	% of population	2015	30.5	2020	21.2	2015	2.2	2020	1.5
	Population connected to at least secondary wastewater treatment	% of population	2015	39.7	2020	51.8	2015	78.9	2020	81.1
Water quality	Biochemical oxygen demand in rivers	mg O_2 per litre	2015	3.97	2020	3.43	2015	3.04	2020	2.65
	Nitrate in groundwater (four-year moving average)	mg NO_3 per litre	N/A	:	N/A	:	2015	23.3	2020	22.6
	Phosphate in rivers	mg PO_4 per litre	2015	0.105	2020	0.107	2015	0.058	2020	0.072
	Inland water bathing sites with excellent water quality	% of bathing sites with excellent water quality	2019	0.0	2021	0.0	2016	82.1	2021	78.2
Water scarcity	Water exploitation index (WEI+)	% of renewable water resources	2014	25.2	2019	9.0	2014	3.8	2019	3.6
SDG 7 – Affordable and clean energy										
Energy consumption	Primary energy consumption	tonnes of oil equivalent per capita	2016	1.6	2021	1.7	2016	3.1	2021	2.9
	Final energy consumption	tonnes of oil equivalent per capita	2016	1.1	2021	1.3	2016	2.2	2021	2.2
	Final energy consumption in households per capita	kgoe	2016	376	2021	458	2016	564	2021	586
	Energy productivity	EUR per kgoe	2016	4.8	2021	5.4	2016	7.8	2021	8.5
Energy supply	Share of renewable energy in gross final energy consumption	%	2016	25.0	2021	23.6	2016	18.0	2021	21.8
	Energy import dependency	% of imports in gross available energy	2016	21.9	2021	31.6	2016	56.2	2021	55.5
Access to affordable energy	Population unable to keep home adequately warm	% of population	2016	13.8	2021	10.1	2016	9.0	2021	6.9
SDG 11 – Sustainable cities and communities										
Quality of life in cities and communities	Severe housing deprivation rate	% of population	2015	19.8	2020	14.3	2015	5.3	2020	4.3
	Population living in households suffering from noise	% of population	2015	22.2	2020	16.1	2015	18.3	2020	17.6
	Premature deaths due to exposure to fine particulate matter ($PM_{2.5}$)	number per 100 000 persons	2015	121	2020	112	2015	73	2020	54
	Population reporting crime, violence or vandalism in their area	% of population	2015	13.1	2020	8.8	2015	13.2	2020	10.7
Sustainable mobility	Road traffic deaths	number per 100 000 persons	2016	9.7	2021	9.3	2016	5.3	2021	4.5
	Share of buses and trains in total passenger transport	% of total inland passenger-km	2015	22.1	2020	18.1	2015	17.6	2020	12.8
Adverse environmental impacts	Settlement area per capita	m^2	2015	364.8	2018	528.4	2015	680.6	2018	703.4
	Recycling rate of municipal waste	% of total municipal waste generated	2016	13.4	2021	11.3	2016	45.9	2021	49.6
	Population connected to at least secondary wastewater treatment	% of population	2015	39.7	2020	51.8	2015	78.9	2020	81.1
SDG 13 – Climate action										
Climate mitigation	Net greenhouse gas emissions	tonnes per capita	2016	4.0	2021	4.3	2016	8.2	2021	7.4
	Net greenhouse gas emissions from land use and forestry (LULUCF sector)	tonnes CO_2 eq. per km²	2016	-146.4	2021	-137.2	2016	-70.3	2021	-50.1
	Share of renewable energy in gross final energy consumption	%	2016	25.0	2021	23.6	2016	18.0	2021	21.8
	Average CO_2 emissions per km from new passenger cars	g CO_2 per km	2016	122.0	2021	126.5	2016	117.6	2021	116.3
Climate impacts and adaptation	Climate-related economic losses (30-year moving average)	EUR per inhabitant	2016	23.8	2021	24.9	2016	27.1	2021	33.9
	Population covered by the Covenant of Mayors for Climate and Energy signatories	% of population	2017	38.3	2022	33.9	2017	40.1	2022	44.3
Financing climate action	Contribution to the international USD 100bn commitment on climate-related expenditure	EUR million, current prices	2016	1	2021	5	2016	19,016	2021	23,043

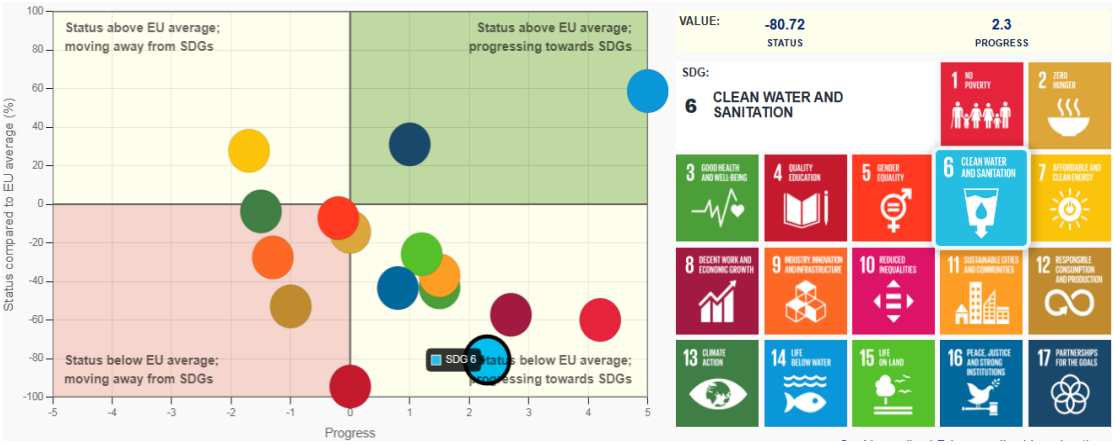


Figure 4: **SDG 6: Clear water and sanitation – ROMANIA |** Source: Eurostat

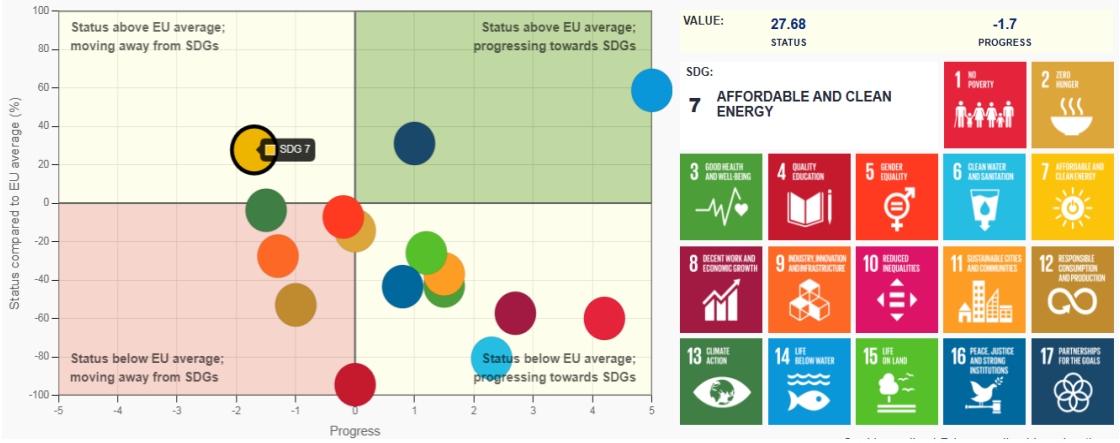


Figure 2: **SDG 7: Affordable and clean energy – ROMANIA |** Source: Eurostat

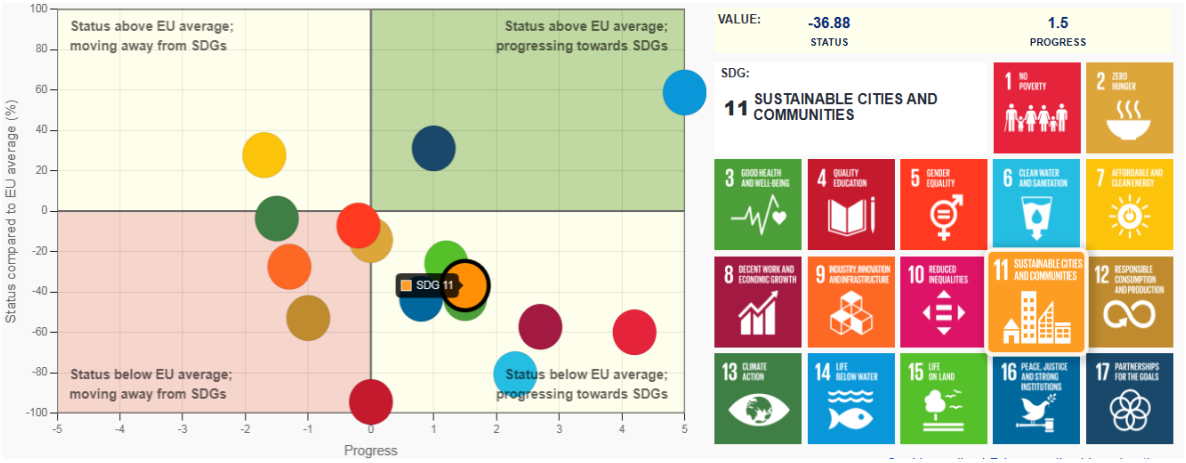


Figure 5: **SDG 11: Sustainable cities and communities – ROMANIA |** Source: Eurostat

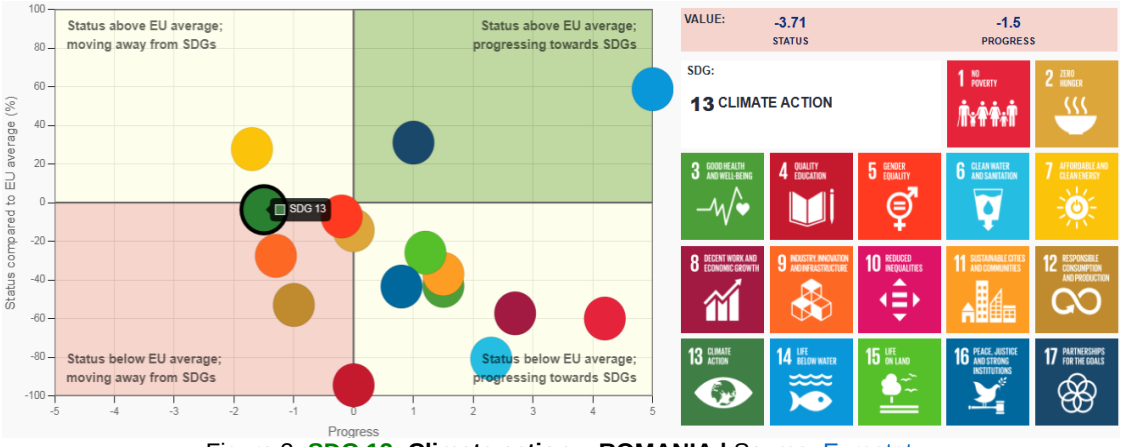


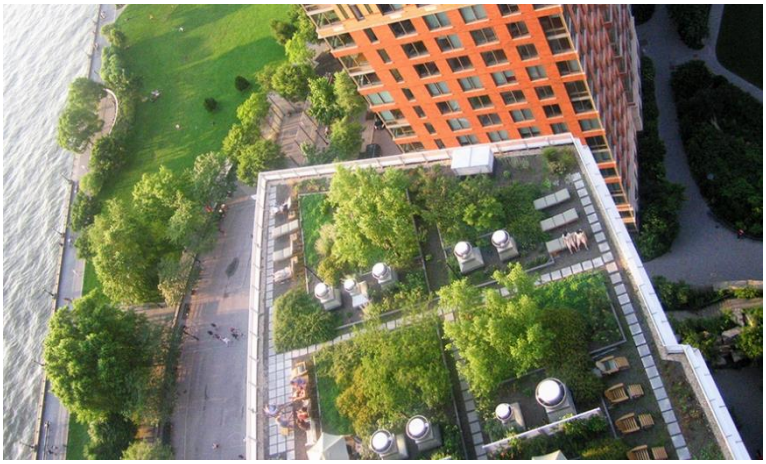
Figure 3: **SDG 13: Climate action – ROMANIA |** Source: Eurostat

3.1. *Eco-friendly practices in construction sector*

According to UN statistics, more than half of world population lives in urban areas. This situation implies an emergency need to identify solutions for a sustainable performance of the buildings we live and work in. Construction sector has the capacity to bring a major contribution to a sustainable future. In the publication ”Sound of Green: Designing for Sustainability in Buildings” (State of Green, 2023) it is mentioned that “*buildings incorporate more than 40% of the energy consumption during their lifetime”*.

Talking about sustainable constructions means providing long-term viability by referring to a wide diversity of topics, like: sustainable design and ecologic building management, performant materials, energy efficiency in construction, operation and maintenance, long term monitoring, etic standards, eco-friendly technology and products, innovative financial models, current conditions improvement, interdependence between environment, infrastructure and urban architecture; flexibility in constructions usage, functioning and change; knowledge dissemination; development and innovation in new and composite materials, nanomaterials, recycling old materials by their incorporation in new products and so on. Just one question: what better way to expose the put into practice of *sustainability* concept than presenting one segment of sustainable development application in constructions by including the "green roofs"?. This constructive component consists of vegetation surfaces on buildings roofs. It is present for centuries, mainly on the houses from North and West of Europe. In 20th century, the innovations in design and concerns for environmental impact of buildings lead to a legal request for green roofs in several European countries.

According to the statistics made in January 2023 on Green-roofs market (TechnavioPlus, 2023), it was identified an increase estimated at ***12.18%*** *between 2022 and 2027, representing a value of* ***USD 8,106.69 million***. The growth of the market depends on several factors, including a reduction in global warming due to green roofs, better management of rainwater runoff flow, and supporting policies. Moreover, according to Building Radar (2023) and European Federation of Green Roof & Wall Associations, *Germany has the greatest share of green roofs within Europe*. The industry benefited from government policies, since this type of construction element is considered as providing beneficial services for the local community. After becoming so popular in EU, "green roofs" arrived in USA, being considered as a durable and attractive solution for commercial buildings.



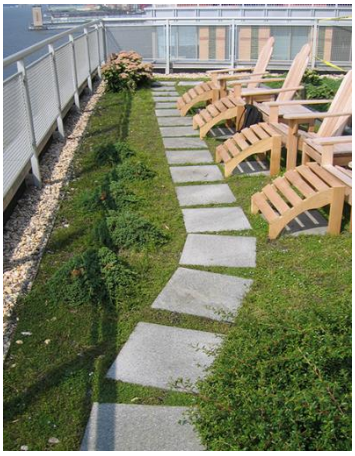


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Figure 6: The Solaire, NYC, is the first green residential building in the U.S. | Source: The Solaire (2003),

Figure 7: Moesgaard Museum, Højbjerg, Denmark | Source

Green roofs gained lately significant popularity in the area of design as a sustainable and aesthetical urban solution. Their structural system is a combination between a waterproofing roof over which is applied another layer that can support, partially or in total, a natural environment made of plants. This type of roofs is specially designed to be autonomous and easy to maintain, providing a roof system that is adapted to our days, when people became more interested in environment protection and improvement of air quality.

Figure 8: Fukuoka Prefectural International Hall of Japan | Source

The “green roof” can also be found under the name of “ecologic roof” or “garden roof”, and represents in fact a stratified roof, which is capable to raise plants on its flat or slightly sloped waterproof substrate. In comparison with traditional roof systems, green roofs have a longer life expectancy, they reduce the energy costs due to natural insulation, improve the air quality and absorb rainwater. These types of roofs can be divided into two general categories: intensive and extensive (Building Radar, 2023). In between these two generic types, there are several ecologic solutions, including semi-intensive and semi-extensive.

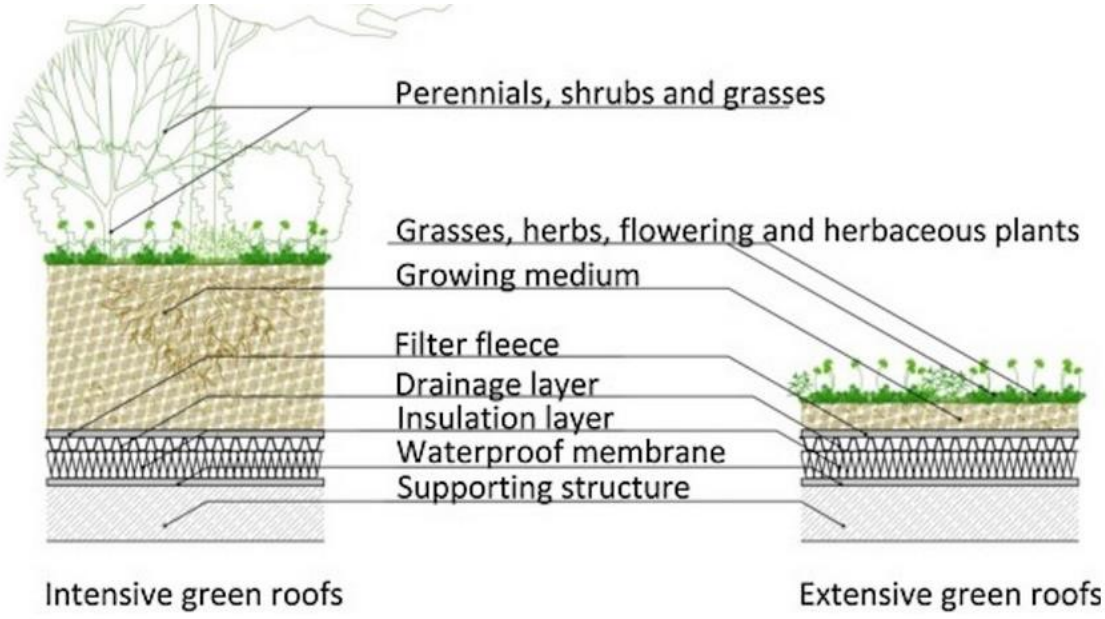

Figure 9: Types of green roofs | Source

Intensive green roofs have a deep growth environment, which allows the use of trees and bushes. Several parks are actually, intensive green roofs, like parks from Wharf Estate Canary in Canada Square and Westferry Circus, but also the roof of Cannon Street Station from London. The depth of growth environment increases the request for the construction structure strength and implies a complex irrigation system for maintenance. Shortly, intensive roofs are highly costly and imply a complementary structural design of the building.

Figure 10: Canary Wharf Residential | Source

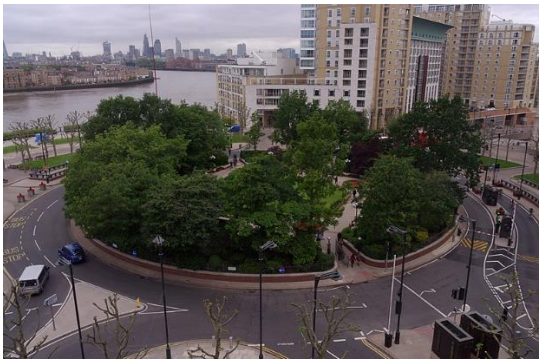

Figure 11: Westferry Circus | Source

Figure 12: Cannon Rail Station, London | Source: John Gaffen, Alamy Stock Photo

Extensive green roofs have a reduced growth environment, they imply a minimal maintenance and in general they don't require an irrigation system. Generally, are less costly than intensive green roofs.

Figure 13: Nanyang Technological University, Singapore | Source: 15 Interesting Green Roofs From Around the World,

Figure 14: Restaurant from Porumbacu de Sus village, close to Sibiu City, Romania | Source: https://valeazanelor.ro

An interesting example of combined intensive and extensive green roof can be found on a building from Milano, Italy. This construction is famous for the vegetation planted on the exterior of the building, in each apartment. Due to its looks, the construction is named "Bosco Verticale" or Vertical Forest. A detailed presentation of the project can be seen at the following link

Figure 15: Building in Milano, named "Bosco Verticale" | Source

In the "Living Roofs and Walls. Technical Report: Supporting London Plan Policy" (Greater London Authority City Hall, 2008) can be found useful information on these types of structures, but most important on the financial implications of such an investment. According to the same source, green roofs costs are known for their difficult evaluation, due to the fact that there exists a significant number of factors that modify the price per square meter. Among these factors can be mentioned (Greater London Authority City Hall, 2008):

- *Roof size*. Small roofs can be very expensive. Such an example can be a small roof from London centre that costed 185£/square meter. As the constructive area increases, the price per square meter reduces;
- *Roof weight*. This aspect will modify the price as related to the lifting costs of the elements to the roof level;
- *Green roof type requested*. As related to the extension of the green roof, an instant green will imply the use of sedum mats plants that are more expensive than sedum plug plats. The cheapest option is usually the hydro sowing, but will last some time until the plant will reach the desired green effect. The roofs conceived for biodiversity might as well be cheaper if will be sowed with a mix of right plants or allowing them to develop by their own vegetal process;
- *Initial maintenance and installation costs*. Although sedum plug plants can be less expensive per square meter, will be a cost regarding the roof stability in the first two years regarding irrigation and weeding;
- *Waterproofing and isolation type used*. Different waterproofing systems ask for different applications, additional to different work force costs;

- *Producers and contractors involvement*. Quite often green roofs are inaccurate as price, their builders don't give detailed plans from the very beginning but only when the roof has already been conceived;
- *Installation methods*. Usually, it is necessary that the installation to be monitored in order to provide the specific concept and to follow the necessary specifications (especially in the case of roofs conceived for biodiversity).

According to the article "Advantages and Disadvantages of Green Roofs", on the Green Roofers website, the green roofs provide a significant number of benefits to the environment, which compensate for the initial costs:

- Provide thermal insulation which saved energy costs and reduces the production of CO2. In general, the plants from green roof activity reduces the quantity of CO2 from the atmosphere;
- Contribute to ozone reduction production by decreasing the global warming effect and by absorption of air particles;
- Create barriers against noises and provide sound insulation for buildings positioned below airplane routes or close to airports;
- Provide the habitat for a valuable wild fauna in the big cities and can help in the realisation, at local and regional level of biodiversity objectives;
- Create an environment of physic and mental relaxation;
- Significantly reduce rain runoff from buildings.
- Bring biodiversity benefits more than traditional roofs.

If not man made, the nature itself gives us examples of green roofs as can be observed in figure 16 below.

Figure 16: Architecture Durable (21) | Source

In order to better understand the construction process of a green roof, it is important to know which are the main layers found in the green roof structure. For a detailed presentation of the constructive process, the Youtube link can be consulted.
Urbanscape green roof is a complex system, with reduced weight, composed of an anti-root membrane, a drainage system, an unique substrate patented based on basaltic mineral cotton and vegetation layer.

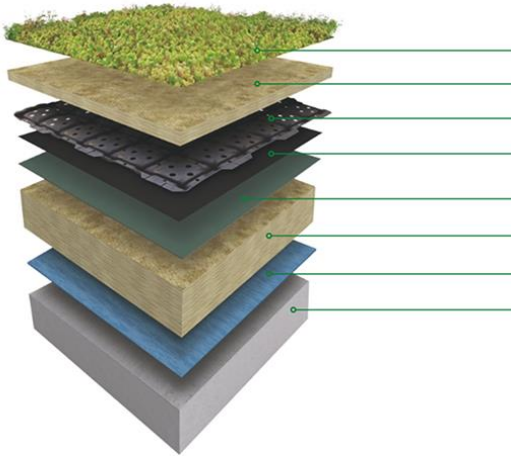

Figure 17: Green roof system (22) | Source

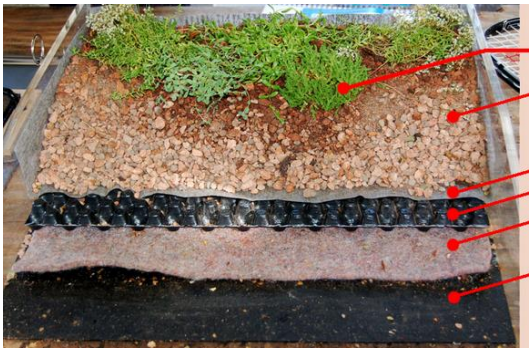

Figure 18: Green roof layers | Source

4. Recommendations

- Sustainability as key development concept was adopted by all areas of activity. What interests mostly is the applicability of the sustainability principles. In this context, the technical sector creates a connection bridge between theory and practice in the area of sustainable development;
- European Union grants a significant importance to the environmental issue, so that all member countries must implement joint policies and associated measures;
- Sustainability 2030 Agenda details on a number of 17 Sustainable Development Goals (SDG). Since its adoption, EU made progress across a large majority of the SDGs. Following the international trend, Romania also integrated the "sustainability" concept into its practices in all areas of development.
- Construction of green roofs is positioned on an increasing trend in urban architecture since the process has significant benefits, mainly because they improve life quality by reducing air pollution. The roofs system is composed by a wide diversity of plants. In short, green roofs are well worth considering when planning for a building.

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ABOUT

Jean Monnet Module on EU Interdisciplinary Studies:
Widening Knowledge for a more Resilient Union | EURES
PROJECT NUMBER – 621262-EPP-1-2020-1-RO-EPPJMO

The reasons laying behind the project are related to the harsh economic challenges the EU is currently facing, the youth being mostly affected by very high unemployment rates. Thus, encouraging academic debates on how can young population acquire more competences and ease its labour market integration may be the key for reviving European economy (a more resilient EU).

All activities proposed in the project have an interdisciplinary and multidisciplinary character: the events are aimed at specialists in various EU issues (regional development, health, European funding opportunities, methodological aspects); the target audience consists of students, teachers, researchers, broad public – having different profiles and professional backgrounds; the topics of the events organised (seminars, workshops, round tables) cover many perspectives: economic, social, political, medicine, engineering etc.

EURES project is coordinated by Ramona Tiganasu, researcher at Centre for European Studies

The Centre for European Studies (CES) is an interdisciplnary department within the Faculty of Law from Alexandru Ioan Cuza University of Iasi, Romania and operates as a Jean Monnet Centre of Excellence in European Studies, from 2009.

CES's mission is to contribute to the development of the European dimension of education, to promote research and consultancy, information, documentation in the area of European studies and to, directly and indirectly, support the process of economic and social development in the North-East region of Romania.