An evaluation of the knowledge of the Sustainable Development Goals and Black Carbon within the higher education systems of northern Finland and Norway, and in Kola Peninsula, NW Russia

Capacity Building for Black Carbon mitigation (CB4BC) project
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Abstract

Climate change is a global problem. Black carbon (BC) is a strong climate forcer that absorbs light particles, influences cloud formation and increases the melting rate of snow and ice. It has a short life span and is often deposited not far from the source. It is also an air pollutant that causes a great variety of health problems. BC is already included in international legislation around climate and air pollution but there are limited legal commitments that directly address it. As part of the Kolarctic Cross Border Cooperation Programme, the project Capacity Building for Black Carbon mitigation efforts (CB4BC) aims to create a roadmap for mitigation in northern Finland and Norway, and in NW Russia. This thesis study aims to support the project in two ways. First, it creates an overview of the current situation of BC emissions and sustainability practices in the three countries. Second, it evaluates the level of knowledge of BC and the Sustainable Development Goals (SDGs) among students and teachers in universities. This also includes investigating the main information channels and collecting opinions and suggestions on current mitigation strategies.
To test the hypotheses that the knowledge of BC and the SDGs differs between the three regions, students and teachers, genders, age, sectors, years of involvement at university and income, an online survey was distributed. It was sent internally within one university per region, resulting in a total of 307 student and 34 teacher participants. The responses were analyzed in SPSS using a Kruskal-Wallis and a post hoc Mann-Whitney U tests. Analysis among the teachers used the Fisher's exact test as a more conservative approach due to the limited data. Bonferroni adjustment was used for the p value. The only differences found were on the knowledge of the SDGs between Finland and Norway, and between teachers and students. Analysis between countries can however not be used to draw reliable conclusions, due to possible bias as a result of the uneven response rate across the countries. Therefore, this report reflects best the situation within Finland. University and publications were the main information channels for teachers, whereas students focused more on news and social media. Educators were more aware of governmental practices. Both groups thought that universities should be more eco-friendly and integrate the topics better. Multiple initiatives on energy efficiency, food alternatives and the integration of the knowledge were listed. The results suggested that even though teachers knew the SDGs better, the topic was not integrated enough in lessons. Knowledge of the SDGs is found to still be fragmented in the university education.
To successfully combat climate change, awareness and knowledge of the SDGs and BC among the young generation especially must increase. The universities, being among the most important information channels on the topics, have the obligation to provide reliable information and motivate students to take action. An interdisciplinary integration combined with an innovative communication strategy will be suitable for the higher education system.

Key words: black carbon, SDGs, mitigation, cross border cooperation, Kolarctic CBC Programme, Capacity Building for Black Carbon mitigation (CB4BC) project

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List of symbols and abbreviations

Capacity Building for Black Carbon mitigation project	CB4BC
Black carbon	BC
Short-lived climate forcers	SLCFs
International Convention for the Prevention of Pollution from Ships	MARPOL
Convention on Long-range Transboundary Air Pollution	CLRTAP
National Emissions Ceiling Directive	NEC Directive
Particulate matter with a diameter of 1.0 micrometres or smaller	PM1.0
Particulate matter with a diameter of 2.5 micrometres or smaller	PM2.5
Particulate matter with a diameter of 10 micrometres or smaller	PM10
Kolarctic Cross Border Cooperation Programme	Kolarctic CBC Programme
Lapland University of Applied Sciences	LUAS
Uit The Arctic University of Norway	Uit
Sustainable Development Goals	SDGs
DPSIR Framework	Driver-Pressure-State-Impact-Response Framework
Murmansk State Technical University	MSTU
Organic carbon	OC
Volatile organic compounds	VOC
Greenhouse gasses	GHG
District heating	DH
International Cryosphere Climate Initiative	ICCI
International Maritime Organization	IMO
Arctic Monitoring and Assessment Programme	AMAP
Arctic Council's Arctic Contaminants Action Program	ACAP
National Energy and Climate Plan	NECP
National Air Pollution Control Programme	NAPCP
EU Emissions Trading System	EU ETS
On the land use, land use change and forestry	LULUCF
United Nations	UN
Sustainable Development Goal: Life on land	SDG15
Sustainable Development Goal: Life below water	SDG14
Sustainable Development Goal: Climate action	SDG13
Sustainable Development Goal: Responsible consumption and production	SDG12
Sustainable Development Goal: Sustainable cities	SDG11
Sustainable Development Goal: Promoting innovation within the industry and infrastructure	SDG9
Sustainable Development Goal: Access to clean water and sanitation	SDG6
Sustainable Development Goal: Quality education	SDG4
Sustainable Development Goal: Human health	SDG3
Sustainable Development Goal: Zero hunger	SDG2
Sustainable Development Goal: No poverty	SDG1
Non-governmental organizations	NGOs
United Nations Educational, Scientific and Cultural Organization	UNESCO
Global Action Programme on Education for Sustainable Development	GAP ESD
Research Development and Innovation	RDI
Research and Development	R&D
University of Bergen	UiB

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1 Introduction

1.1 Problem statement

Climate change is a global problem that causes the loss of biodiversity worldwide, as well as all kinds of other socioeconomic problems. Black carbon (BC) emissions contribute currently a huge deal to the climate threatening emissions. They impact the amount of solar energy that can reach the earth's surface through absorbing light particles and influencing cloud formation (Saxena and Chandra, 2011; Winiger et al., 2017). Small concentrations of BC have a significant impact on the formation of snow and ice with potential devastating effects on the Arctic region (Kholod, Evans and Malyshev, 2015). Furthermore, research on this aerosol concludes that it can lead to a variety of health problems such as premature deaths and cardiovascular diseases (Kholod, Evans and Malyshev, 2015; Harmsen, 2020).

The BC emissions can travel long distances in the amosphere but their short life span can lead to a fairly quick deposition. The Arctic States are responsible only for 10% of global BC emissions but contribute to the effect of BC on the Arctic with up to 30%. This means that their proximity plays a vital role in the mitigation of this substance (The Arctic Council, 2021). When focusing on mitigation measures within Europe however, reducing emissions in the Scandinavian countries has great potential to achieve short term environmental goals (Winiger et al., 2017).

Currently as a climate forcer, BC is regulated as part of the short-lived climate forcers (SLCFs) under the Kyoto protocol, the Gothenburg Protocol and the Paris Agreement. As an air pollutant BC is part of regulation on particiculate matter under the International Convention for the Prevention of Pollution from Ships (MARPOL) and under the Convention on Long-range Transboundary Air Pollution (CLRTAP) (EIB, 2016; Shapovalova, 2016). There are also multiple voluntary initiatives and working groups, part of the Arctic Council that are involved in BC mitigation (Timonen et al., 2019; Arctic Council, 2021). The EU uses the National Emissions Ceiling Directive (NEC Directive) as a legal instrument to directly address BC in the form of particulate matter with a diameter of 2.5 micrometers or smaller (PM2.5) and the EU Green Deal that has made commitments to reach climate neutrality by 2050 (EIB, 2016; Lee-Makiyama, 2021).

Furthermore, the Kolarctic CBC Programme grants financial support to projects that work towards protecting the Arctic region, often through adressing common challenges that are of great importance to the environment, health and safety of the community, society and economy (Kolarctic CBC, 2020). An example of this initiative is the project around which this thesis revolves around, Capacity Building for Black Carbon mitigation efforts (CB4BC). It aims to create a roadmap that can be used as a tool for strategic decision making by companies and organization in Finland, Norway and Russia. It will improve communication, coordination and understanding of mitigation measures. For this purpose the cooperation of partners from Finland (Lapland University of Applied Sciences), Norway (Uit The Arctic University of Norway) and Russia (Kola Science Center of the Russian Academy of Sciences) is needed to collect information on the current status of BC and all relevant mitigation strategies. The project separates technoeconomic elements, socioeconomic goals and preconditions and cross-border viewpoints from each other, as to seek the right expertise easier.

Since BC contributes to climate change, it also affects the achievement of the Sustainable Development Goals (SDGs) (Fuso Nerini *et al.*, 2019). Therefore, it is important to address both BC and the SDGs for a successful mitigation. Currently, the youth is more than half of the world's population, meaning that the academic institutions have a great obligation to integrate this knowledge into the education system (AIESEC, 2016). This knowledge is still missing, with multiple surveys showing that the term SDGs is well known, while the concept is poorly known. Country specific data is however still missing or fragmented (Schlange, Frank and Cort, 2020; European Union, 2017; AIESEC, 2016).

Therefore, this thesis aims to help with data collection through a literature study and a survey. The literature study bundles information on BC in Finland, Norway and Russia and presents it in the form of the DPSIR (Drivers-Pressures-State-Impact-Responses) assessment framework. The questionaire is used to evaluate the knowledge between students and teachers on the topic of BC and the SDGs. It focuses on the regions of Lapland, Troms and Murmansk, where the partner universities are targeted. More specifically, the survey aims to collect enough data to compare the level of knowledge of the topics between regions, students and teachers, genders, age groups, sectors, year at the university and income. Furthermore, the main channels of knowledge of environmental problems are determined. Opinions on governmental and university practises are collected, as well as possible suggestions on mitigation measures and improving knowledge across the universities.

1.2 Objectives

The objective of the thesis itself is to contribute to the creation of a roadmap for Black Carbon mitigation. This revolves around organizing two workshops with partners from Finland, Norway and Russia, as to share information on BC and improve cross-border coordination. A broad literature study that help give an overview of the state of emissions in the three countries. An article, posted internally at the Lapland University of Applied Sciences (LUAS) website aims to raise awareness on the matter.

Furthermore, this thesis focuses on collecting data among teachers and students on the current knowledge of the SDGs and BC in the education systems of Lapland, Troms and Murmansk. This helps identify any gaps of knowledge, as to find ways to improve the education practices. The focus is the young generation that will be responsible for the future reduction of emissions. For a successful mitigation strategy, it is important that information around the SDGs and BC is clear and accessible.

1.3 Research questions

A questionnaire aims to collect data from the partner universities in Lapland (Lapland University of Applied Sciences), Troms (Uit The Arctic University of Norway) and Murmansk (Murmansk State Technical University). This aims to answer the following questions:

1. What is the level of knowledge of the SDGs and BC of students and teachers?
2. Are there significant differences in the level of knowledge of these topics between:
   A. Regions?
   B. Students and teachers?
   C. Genders?
   D. Age groups?
   E. Sectors?
   F. Years of involvement in the university?
   G. Incomes?
3. What are the main channels students and teachers use to learn about these topics?
4. What are the opinions of students and teachers on the governmental practices and laws, related to SDGs and BC?
5. What are the opinions of students and teachers on the university practices and the integration of the topics?

1.4 Scope

This thesis is based on a literature study and the data analysis of the questionnaire between students and teachers in the three regions. The survey and the literature study are used to answer the research questions, evaluate the status of knowledge of the SDGs and BC and make valuable suggestions on possible improvements within the universities. The writing of an article is part of the project, as well as the study program of the PXL university. The end rapport and research findings are presented to a jury, made up of the PXL mentor, Kris Moors, a second reader from PXL and the promotors from LUAS, Anne Saloniemi and Jussi Soppela.

1.5 Organization of the rapport

This report focuses on BC and the SDGs. The first part is a literature study that closely examines the sources, state, impacts and legislation of BC, where possible with information per country. The information is then bundled and presented in a DPSIR assessment framework diagram. The second part of the literature study goes deeper into the relation between BC and the SDGs, as well as the importance of an interdisciplinary approach in the education systems. The integration of sustainability within each country is then discussed. The methodology refers to the data collection and analyzation methods. This leads to the results of the survey, discussion and conclusion. The survey questions are attached in appendices at the end of this report.

2 Literature review

2.1 What is Black Carbon?

BC is an operational term for carbon that is measured by means of light absorption (WHO, 2012). It is a major component of soot and is emitted by incomplete combustion of fossil fuels, wood and biomass. Often it is accompanied by other combustion by-products such as organic carbon (OC), carbon monoxide, methane, volatile organic compounds (VOC) and greenhouse gasses (GHG) such as carbon dioxide (UNEP, 2011; EUA-BCA, 2021).

Along with methane and ozone, BC is considered part of the SLCFs. This means that it has a short lifespan, ranging between a few days and ten years (Norwegian Environment Agency, 2021). BC emissions exist in the form of tiny particles, often as particulate matter with a diameter of 1.0 micrometres or smaller (PM1.0). Since there are no laws that regulate PM1.0, BC has been included in the PM2.5 regulation. Measures on these larger particles also reduce PM1.0 but not as effective, urging future regulations to separately focus on BC PM emissions (EUA-BCA, 2021).

2.2 Black Carbon emissions

The world's population is growing, causing an increase in the use of energy and natural resources (AMAP, 2017a). Energy demand keeps rising, with an expected growth of one-third between the year 2013 and 2040, three quarters of which will be made up of fossil fuels (AMAP, 2017b). There are slightly different drivers of emissions between the sub-regions, influenced by the local policies, resource availability and actions of institutions. The main contributors however remain the same (AMAP, 2017a).

2.2.1 Finland

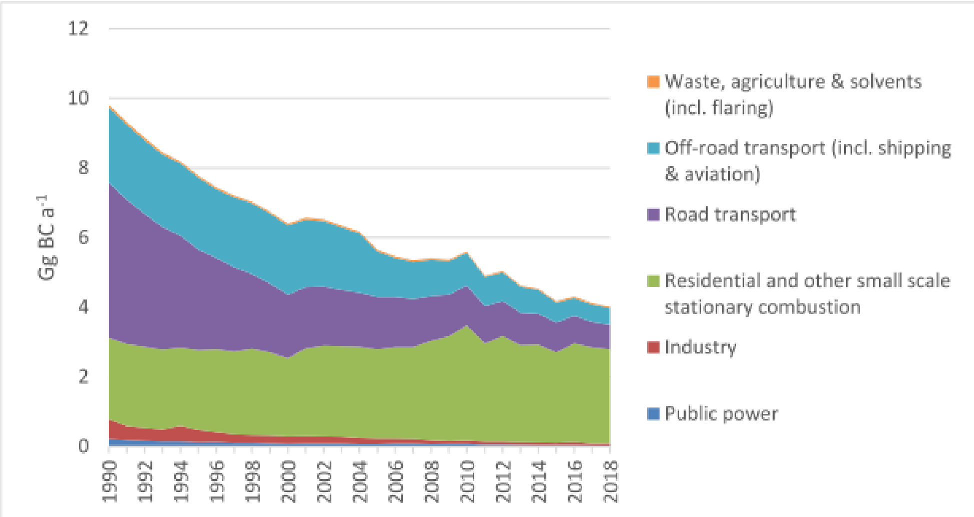


Figure 1: Black Carbon emissions per sector in Finland (1990-2018) (Finnish Environment Institute, 2020, 2021)

Residential wood combustion and transport remain the biggest emitters of BC emissions in Finland (Figure 1). There are however more regulations that apply to the transport sector such as engine update and emission after-treatment. This has significantly decreased emissions from on- and off-road vehicles and machinery. Current projections are that in 2025 the transport sector will be responsible only for 13% of emissions, whereas in 2013 it was 34%. Wood combustion is harder to regulate and remains the main source of BC emissions (Finnish Environment Institute, 2020, 2021). Sauna stoves contribute greatly to these statistics, accounting for 35% of PM2.5 emissions and 45% of BC emissions in 2010. Manually stoked boilers and masonry heaters are also important sources of emissions (Savolahti *et al.*, 2016).

Even with stricter regulations that increase the efficiency of residential wood combustion, the consumption of wood has been increasing in the last four years. There has also been an increase in the burning of forest chips, forest industry by-products and recycled wood. In 2019, wood was the most significant heat source used in Finland, accounting for 28% of the total energy consumption (LUKE, 2020). The overall energy consumption of Finland has been fluctuating in the last 10 years with a positive trend in the last few years. Fossil fuel use is decreasing, while renewable energy sources are increasing, currently making up to 40% of total energy consumption (OSF, 2020). 51% of the total electricity in Finland is produced by renewable resources such as water, wind, solar, biomass and ground heat. Bioenergy is also produced, generated by biodegradable waste (Ministry of Economic Affairs and Employment, 2021).

The region of Lapland also produces a great deal of energy such as hydropower, local wood fuels, peat and waste liquor from the forest industry. Lapland is almost self-sufficient with 90% of electricity coming from renewable energy sources. It supplies electricity to the rest of Finland (Lapland Chamber of Commerce, 2014).

Table 1: PM2.5 emissions Finland, Recalculations of official Convention on Long-range Transboundary Air Pollution, national submissions of priority pollutants, Inventory review report 2020 (unit:%) (CEIP, 2020)

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Finland	-0.1%	0.%	-0.1%	-0.3%	-0.4%	-0.3%	-0.1%	-0.1%	-0.1%	0.2%	0.2%

Table 2: Black Carbon emissions Finland, Recalculations of official Convention on Long-range Transboundary Air Pollution, national submissions of priority pollutants, Inventory review report 2020 (unit:%) (CEIP, 2020)

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Finland	0.2%	0.%	-0.1%	0.1%	0.1%	0.1%	0.3%	0.3%	0.3%	0.3%	0.3%

Even though more renewable energy is used, the increased consumption of wood is reflected on the total PM2.5 and BC emissions. Instead of a decrease due to regulation, emissions have been quite stable or have even slightly increased (Table 1;Table 2). BC was recognized earlier under the form of soot, whereas PM2.5 emissions have only been included in Finland's air quality monitoring in the last 10 years as a result of EU legislation. The air quality limits are currently not exceeded however, the adverse effects of pollutants such as BC on the health and environment call for a stricter regulation (Ministry of Environment, 2019). The mean annual exposure of PM2.5 in Finland is 6 micrograms per cubic meter (The World Bank, 2017). There has not been a consent on the absolute safe levels of PM emissions. A study using the disease burden concept shows that 64% of the human health impacts by air pollutants in the country are caused by PM2.5 emissions (Ministry of Environment, 2016, 2019).

2.2.2 Norway

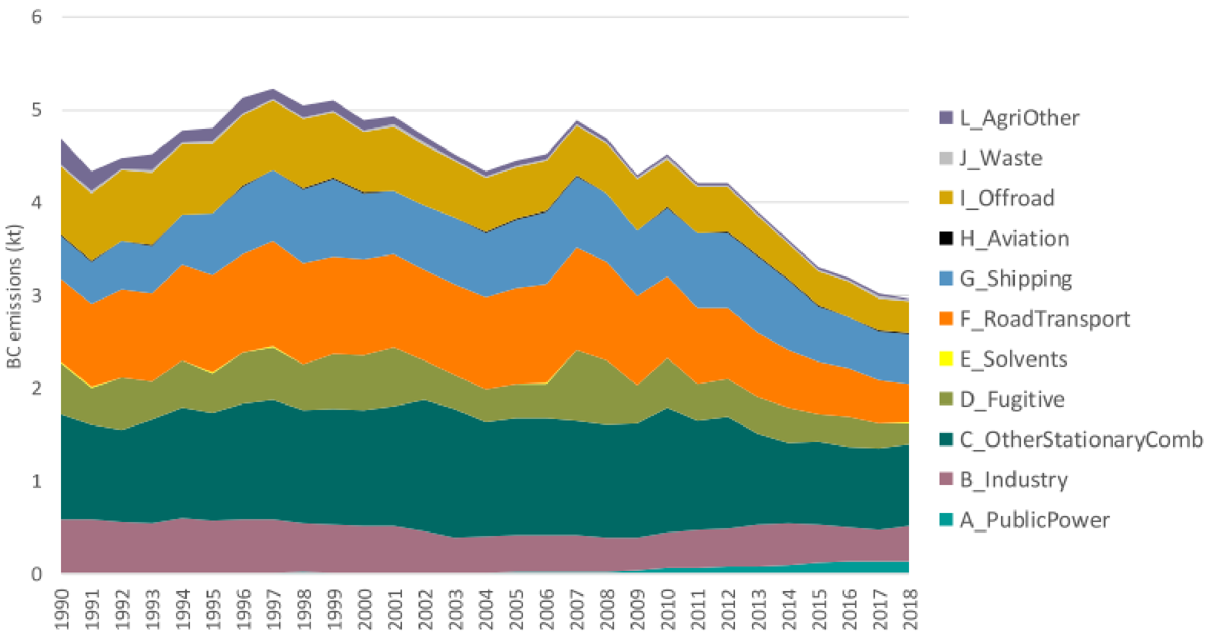


Figure 2: Historical Black Carbon emissions per sector in Norway (1990-2018) (Norwegian Environment Agency, 2014; Arctic Council, 2020; Statistics Norway, 2020a)

In Norway, the transport sector is the biggest source of BC emissions (43%), where 18% come from shipping, 14% from on-road transport and 11% from off-road transport (Arctic Council, 2020). The terrain of Northern Norway is challenging, with many locations lacking a railway network. This leads to an increased sea and road movement (Lapland Chamber of Commerce, 2014). National stationary combustion also contributes significantly to the BC emissions, accounting for around 30%, 94% of which come from residential wood heating. Gas and oil flaring falls under the category industry, also contributing to emissions. There is a clear decrease in emissions, where a total reduction of around 37% is observed between 1990 and 2020. In the last three years emissions have dropped only with 2%. The projections are that emissions from most sectors will decrease, with the biggest fall in shipping and on road transport emissions (Arctic Council, 2020).

The residential wood heating emissions have decreased with 34% between 2010 and 2020 and this trend is expected to continue due to warmer climate conditions, more efficient stoves and better insulation (Statistics Norway, 2020b; Norway Today News, 2021).

Norway is also a big power producer, with renewable energy accounting for 98% of total electricity production. This is almost fully produced by hydropower. Furthermore, the country is a world producer of natural gas and oil, resulting in a low energy price and high exports. This can be related to the high energy consumption and the upward trend in electricity use (EnerData, 2020; Statistics Norway, 2020b). This availability of alternative energy can however help ease the transition from wood to electricity, and from diesel to electric cars.

Table 3: PM2.5 emissions Norway, Recalculations of official Convention on Long-range Transboundary Air Pollution, national submissions of priority pollutants, Inventory review report 2020 (unit:%) (CEIP, 2020)

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Norway	0.5%	-0.9%	-4.6%	-8.5%	-8.4%	-9.%	-8.4%	-7.5%	-8.6%	-8.7%	-11.4%

Table 4: Black Carbon emissions Norway, Recalculations of official Convention on Long-range Transboundary Air Pollution, national submissions of priority pollutants, Inventory review report 2020 (unit:%) (CEIP, 2020)

	1990	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Norway	2.2%	1.9%	-0.1%	-1.5%	-1.6%	-1.8%	-1.6%	-1.4%	-1.8%	-1.4%	-3.1%

The use of renewable energy reflects positively on emission trends after the year 2000, where BC emissions decreased with more than 14% and PM2.5 emissions with almost 50% (Table 3; Table 4).This also corresponds with the measures and the reduction of emissions overall (NILU, 2018). According to NILU, Norway's rural areas have some of the lowest PM levels in the EU. That fact however does not conclude that other pollutants such as ozone are within the limits, as data from 2018 shows (NILU, 2018). The latest record of the mean annual exposure of PM2.5 in Norway is 7 micrograms per cubic meter (The World Bank, 2017). There has been estimated that more than 1400 deaths annually are related to PM2.5 and ozone emissions (Forouzanfar *et al.*, 2016; NIPH, 2017).

2.2.1 Russia

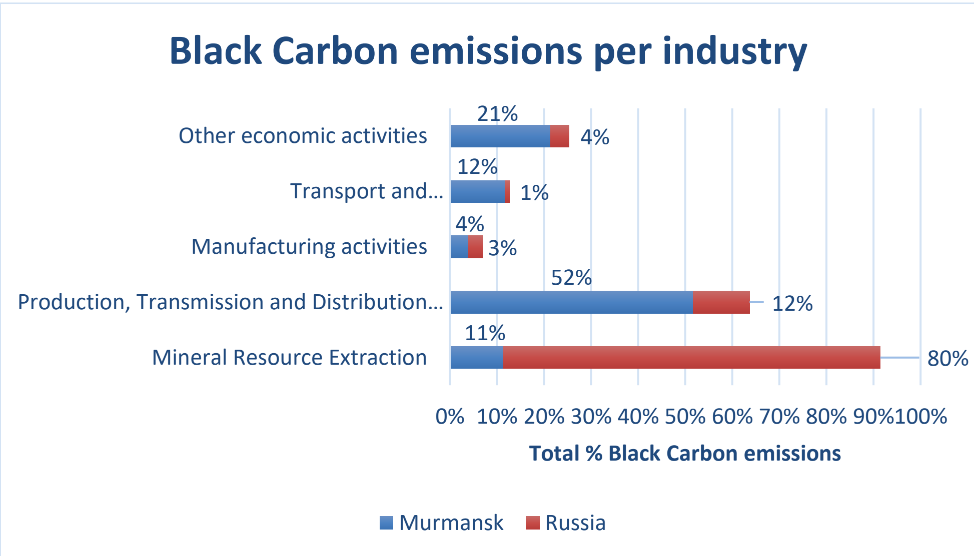


Figure 3: Black Carbon emissions per industry (calculated from tons) in Russia and Murmansk Region (Federation, 2015)

Russia's largest source of BC is the mineral extraction, accounting for 80% of total BC emissions. The sectors responsible for the production of energy account for 12%, followed by manufacturing, transport and a very small portion of agriculture and forestry. In Murmansk, the biggest contributor of emissions is power production, followed by other economic activities and transport. Under other economic activities falls real estate, agriculture, hunting and forestry and part unidentified (Figure 3).

When only diesel related emissions are evaluated, the most BC emissions originate from off-road vehicles within the industry, agriculture and rail. Locomotives for example are often outdated and run on diesel and mining machines that don't have the required emission controls (Kholod, Evans and Kuklinski, 2016). Murmansk Region itself has a lot of industry where the biggest emitter of BC and PM emissions are the mining operations, accounting for up to 70% of all diesel emissions in the region (Evans *et al.*, 2015). The region has great raw material resources, with over 60 deposits of various raw materials that have national and international importance. The economy of the whole Kola Peninsula revolves around the mining industry (Lapland Chamber of Commerce, 2014).

Russia is also the fourth biggest emitter of BC by forest fires. However they are considered naturally-caused are therefore not taken in the governmental data on anthropogenic sources (Federation, 2015).

Russia is still increasing coal and natural gas production (IEA, 2020b). The demand for fossil fuels in Russia is high, with 53% demand for natural gas and 18% for oil-based fuels. Nuclear energy and hydropower are state funded, making them the biggest carbon free energy sources on the market. All the renewables combined, including hydropower still made up only 3.2% of the total primary energy consumption in 2015 (Mitrova and Melnikov, 2019). However, this is expected to increase to 4.9% by 2035 (Alekseev *et al.*, 2019; Mitrova and Melnikov, 2019). Potential increase is much higher, given the right regulations are applied. The IRENA rapport discusses the potential prospects of renewable energy development.

The total energy consumption of Russia has slightly increased over the last decades. The industry, buildings and transport are the biggest consumers. In addition to natural gas, electricity, oil and district heating (DH), the industry is the main sector still using coal. The transport sector mainly relies on oil products with some natural gas and electricity, whereas the residential sector is mostly made up of DH and natural gas (IEA, 2020a).

The mean annual exposure of PM2.5 in Russia is 16 micrograms per cubic meter (The World Bank, 2017). In addition to this high concentrations, the country accounted for nearly 74 thousand deaths, possibly related to PM emissions in 2019. This has increased in comparison with the previous year (Statista, 2021). There are still uncertainties when it comes to measuring BC. Ruppel *et al.* states that BC emissions have gradually decreased with some fluctuations, levelling off between 2000 and 2015 and then slowly declining again.

2.2.2 An overview of Black Carbon emissions in Finland, Norway and Russia

When we look at the sources of BC in the three countries, it is clear that transport and residential wood combustion are the biggest emitters.

In Finland, wood combustion for heating is an alternative, used for many years due to availability and lower price. Here the sauna stoves and manually stokes boilers are the greatest contributors due to the lack of regulation and monitoring around their use. In addition to these sectors, Norway is a world gas and oil producer and has significant BC emissions coming from gas flaring. However, the big production of electricity in the form of hydropower means lower prices and greater availability, making the transition to electricity much easier. Even though Russia faces similar problems in the transport and residential sector, the production of coal and gas in the form of mineral extraction contributes the most to emissions. In Murmansk Region, it seems that the production, transmission and distribution of power, gas and water contribute the most to BC emissions. After closely looking at emissions from diesel use, the industry and the mining operations are yet again the biggest emitters. The transition to renewable sources in Russia is going much slower than in Finland and Norway, with renewables making up less than 5% of the total energy production. Nuclear power is a more common alternative because of state funding, making it cheaper and more accessible. There is still a lot of unexplored potential for energy production in Russia.

The consumption of energy in all three countries is quite high, with an upward trend in demand for energy. The energy type used however plays an important role in the BC and PM2.5 emissions. The high wood consumption in Finland is somewhat reflecting on the emission trends, where PM2.5 emissions are barely decreasing and BC emissions have even slightly increased over the past decade. Norway has been doing well in reducing emissions due to the high use of renewables and a decrease of wood combustion. There has been a strong and consistent decrease of BC emissions by almost 14% over the last two decades and an almost 50% decrease of PM2.5 emissions. Even with the strong decrease in emissions, the mean annual exposure of PM2.5 is 7 micrograms per cubic meter, while in Finland is 6. Russia has a very different situation, where high fossil fuel production and high emissions from the mining industry, transport and residential heating have greatly increased BC and PM2.5 emissions. Currently the mean annual exposure of PM2.5 is 16 micrograms per cubic meter. In combination with the area of the country, this leads to a great number of premature deaths every year, much higher than in Finland and Norway. The monitoring of emissions and regulations in Finland and Norway results in less emissions and a better air quality overall. Stronger emission regulations in Russia and more investment in renewable energy is needed.
The lack of uniform measures and cross-sectoral implementation can form a barrier not only in Russia, but in Finland and Norway as well (AMAP, 2017a).

2.3 Black Carbon impact

2.3.1 Environmental impact

The fine BC particles can sometimes be transported over large distances, along with air masses. However, the short existence of BC means that it often does not travel far from the emission source, affecting the climate conditions in the surroundings. Because of its light absorbing properties, BC in high altitudes will block the sunlight from reaching the earth and will have a cooling effect, while in low altitudes it will trap heat and increase temperatures. In the Northern countries, BC will often occur in low altitudes due to the colder and denser air. This makes the Arctic states responsible for almost one-third of all BC emissions in the Arctic (AMAP, 2015). Furthermore, BC deposition can decrease the Earth's albedo. The Arctic reflects the sunlight because of the white surface of the snow and ice. It therefore has a high albedo. BC particles darken the surface, decreasing its ability to reflect the light and leading to higher temperatures and faster snow and ice melting (EUA-BCA, 2021).

The increase in temperatures can have a devastating effect on the terrestrial, marine and freshwater ecosystems, creating problems for species depending on ice to survive. Warmer temperatures will influence snowfall patterns, likely causing early snow melting and a change in the hydrological regime that will directly impact local flora and fauna. Varying temperatures can also lead to rain-on-snow that can result in layers of ice, causing locally a temporary lack of food for wild grazers (AMAP, 2017a).

The change of temperature and hydrology can further weaken the ecosystems, endangering the provision of ecosystem services such as water regulation, maintenance of permafrost and storage of carbon. The migration patterns of local wildlife such as wild reindeers can be affected. The newly formed environment will slowly be overtaken by dominant and more resistant species, leading to a decline of native biodiversity. Less biodiversity means less ecosystem resilience and a higher risk of pest outbreaks and wildfires (AMAP, 2017a).

2.3.2 Socio-economic impact

Health

The first exposure limits were recommended as a protection of public health in 1979 (WHO, 1979). In the 90s more research came out that linked Black smoke (BS) with mortality (WHO, 1979, 2012). The lack of possibility to conduct standardized measurements, as well as the different components and health effects of particulate matter led to a more in-depth research. It led to a separation of particulate matter with a diameter of 10 micrometres or smaller (PM10) from PM2.5 (WHO, 2000, 2012). However, there are still no universal methods for measuring BC emissions, making its monitoring and regulation a challenging task (Timonen *et al.*, 2019).

Even with many studies that relate health effects with the short-term exposure to PM2.5, it is still a challenge to determine which ones are caused only by BC. Most studies examine the total effects of PM2.5 particles, a complex mixture of pollutants, and don't focus on BC particles (Achilleos *et al.*, 2017).

What is known is that PM2.5 particles are very small and can penetrate deep into the lungs, leading to all kinds of respiratory problems. They can cause premature deaths and cardiovascular problems, under which the heart, blood and blood vessels can be affected. Studies in toxicology show that BC helps to bring in other chemicals in the lungs, meaning that it is not the only the compound causing problems (WHO, 2012). Health impacts by air pollution can put big pressure on the health system.

Economy

Global warming will lead to the disappearance of sea ice. While this has mostly negative effects on biodiversity, it provides both challenges and opportunities for the economy.

More area for shipping and the exploration of oil and gas will be available. At the same time however frequently changing weather conditions such as storms, big changes in temperature and icing events will make marine operations technically challenging and unpredictable. This applies to the fishing and mining industry as well. There are more possibilities available but each activity faces a higher risk. Mining activities might also require intensive water management, as well as face a change in demand for certain raw materials. However, the change in weather is a global problem that affects infrastructure such as pipelines, grids, harbours and roads, often disrupting mobility, access to electricity, water, goods and services (AMAP, 2017a).

The change in temperature will also impact local activities. The shorter winter season will result in more possibilities for summer tourism, while less during winter. This can impact culture related activities and will force communities to look for other profitable alternatives. Reindeer pastures for example can face difficulties due to extreme weather conditions and habitat fragmentation, making this business harder to manage each year. Also, the local forestry and agricultural sector can partly experience benefits in the form of higher productivity. However, the shorter harvesting season and the decrease of ecosystem resilience will likely lead to decreased productivity (AMAP, 2017a).

2.4 Black Carbon legislation

2.4.1 International

BC is often regulated in the form of SLCFs through climate objectives and air pollution. Internationally, as a global warming forcer it is part of the Kyoto protocol, the Gothenburg Protocol and the Paris Agreement. Furthermore, the International Convention for the Prevention of Pollution from Ships (MARPOL) has set emission standards for particulate matter (EIB, 2016).
The Arctic Council deals with issues related to BC as a climate change driver under the Arctic Council non-binding BC and Methane Framework. This framework obliges the member and observer states to create a rapport, with relevant projects, examples and best practices and suitable mitigation measures. As of 2012, PM2.5 has been included in the Convention on Long-range Transboundary Air Pollution (CLRTAP) (Shapovalova, 2016).
In 2019, the Kyoto protocol was finally adopted by all eighteen states but several members are struggling to comply with the targets and measures (AirClim, 2019). There are however different voluntary initiatives such as the Climate and Clean Air Coalition, International Cryosphere Climate Initiative (ICCI), the International Maritime Organization (IMO) (Timonen *et al.*, 2019), as well as different working groups of the Arctic Council such as the Arctic Monitoring and Assessment Programme (AMAP) and the Arctic Council's Arctic Contaminants Action Program (ACAP) (Arctic Council, 2021).

2.4.2 Europe

Europe (EU) has great interest in the Arctic's wellbeing due to its impact on global climate change, as well as its importance in food and oil production (Romppanen, 2018). Its role in regulation and emissions of BC can have a direct impact on the region (Chuffart and Raspotnik, 2019).
The EU has been developing an Arctic Policy since 2008 (Commission, 2008). The Ambient Air Quality Directive has then set up to regulate PM2.5, as well as the Industrial Emissions Directive to limit particulate matter emissions in the industry (EIB, 2016). In 2014, an integrated EU policy was proposed, in line with the Paris Agreement that also involved the SLCFs (EU Commission, 2016).
In addition to that, the National Emissions Ceiling Directive (NEC Directive) is the first EU legal instrument to directly address BC through making reduction commitments on PM2.5. The EU Green Deal and its commitment to climate neutrality will also have a great impact, binding member states to undertake stricter measures (Lee-Makiyama, 2021). The short life span of BC provides the opportunity to achieve short-term emission reduction goals (UNEP, 2011).

2.4.3 Finland

Finland is working hard towards reducing carbon emissions through its National Energy and Climate Plan (NECP). Its objectives are to achieve carbon neutrality by 2035, become the first fossil-free welfare society globally and improve carbon stocks and sinks both long- and short term. Furthermore, the country will update its existing emission targets, set up by the Climate Change Act (Ministry of Environment, 2015; Ministry of Economic Affairs and Employment, 2019). A legislation has already been adopted to phase out coal energy by 2029. Many policies will come in action between 2019-2023 and an update of the NECP is expected in 2023. The new Medium-term Climate Policy Plan describes measures that ensure the achievement of the emission reduction strategy of the EU. Furthermore, the Climate and Energy Strategy aims to increase the use of renewable energy and energy efficiency (Ministry of Economic Affairs and Employment, 2019).

Other legislation within Finland includes the National Climate Change Adaption Plan 2022 (Ministry of Agriculture and Forestry, 2014) and the National Air Pollution Control Programme (NAPCP) that implement emission reducing commitments of the NEC Directive (Ministry of Economic Affairs and Employment, 2019).

There are however no laws regulating wood combustion, making sauna stoves the highest emission contributor by estimate. There are EU Directives that aim to increase efficiency by design but small-scale replacement and the lack of obligatory measures can mean a small decrease in emissions. For successful mitigation, increasing awareness through citizens' guidance is crucial. Furthermore, initiatives such as increasing zero-or low emission vehicles, best practices for street maintenance or providing guidance on the best tyre options can help reduce transport emissions greatly. In addition to the national measures, municipalities play a major role in translating this to their own region. They are the ones to promote local air quality, grant environmental permits and make decisions on transport and energy production (Ministry of Environment, 2019).

2.4.4 Norway

Norway's foundation of climate legislation is based on international obligations such as those under the Kyoto Protocol. The white paper on Climate policy (2006-2007) describes the national goals and strategies. Since its involvement into the Climate and Clean Air Coalition in 2012, Norway has worked side by side with the EU to promote air quality and act on climate change. By taking part of the EU Climate Strategy, Norway takes part of three different legislations: the Effort Sharing Regulation for non-ETS emissions, the EU Emissions Trading System (EU ETS) and on the land use, land use change and forestry (LULUCF) (Norwegian Ministry of Climate and the Environment, 2018). Furthermore, it has been adapting its goals (Norwegian Ministry of Climate and Environment, 2013), leading to an ambitious emission reduction strategy that aims to transform the economy (Norwegian Ministry of Climate and Environment, 2016). The Norwegian Environment Agency for example ensures that the Climate Adaptation strategy is being implemented, while the governor ensures its implementation on a local and regional level (CBSS, 2019).
In 2017, the Climate Change Act was adopted, where Norway implemented the EU's emission reduction targets for 2030 and 2050. This resulted in the publishing of a new white paper, representing an action plan to fulfil the commitment (Norwegian Ministry of Climate and the Environment, 2021).

2.4.5 Russia

Russia is one of the biggest emitters of GHG globally and therefore plays an important role in climate regulation. It has engaged in the world's emissions reduction through the Kyoto Protocol. However, it dropped out before the second commitment period (Tynkkynen, 2014). The Paris Agreement, adopted by Russia in 2019 has led to a National Climate change adaption plan for 2020-2022. This has been controversial due to the lack of ambition to reduce emissions and develop renewable energy sources (IFRI, 2021). The strategy focuses on the development of carbon sources but does not address energy efficiency, adjustment to EU's energy legislation or the changing demand for fossil fuels (Alekseev *et al.*, 2019). BC regulation includes emission standards that do not include PM emissions. Moscow is only low-emission zone, where the penalty for violation lies very low. On-road vehicles have still not adopted the Euro VI standard and there are very few standards and checks for off-road vehicles. However, there are different initiatives to reduce BC emissions such as an increased production of ultra-low sulphur diesel that promotes modernization and encourages vehicle inspection mechanisms (Kholod and Evans, 2015). Currently, negotiations are ongoing between the EU and Russia, as to implement the EU Green Deal (Maslova, 2021).

2.5 DPSIR framework

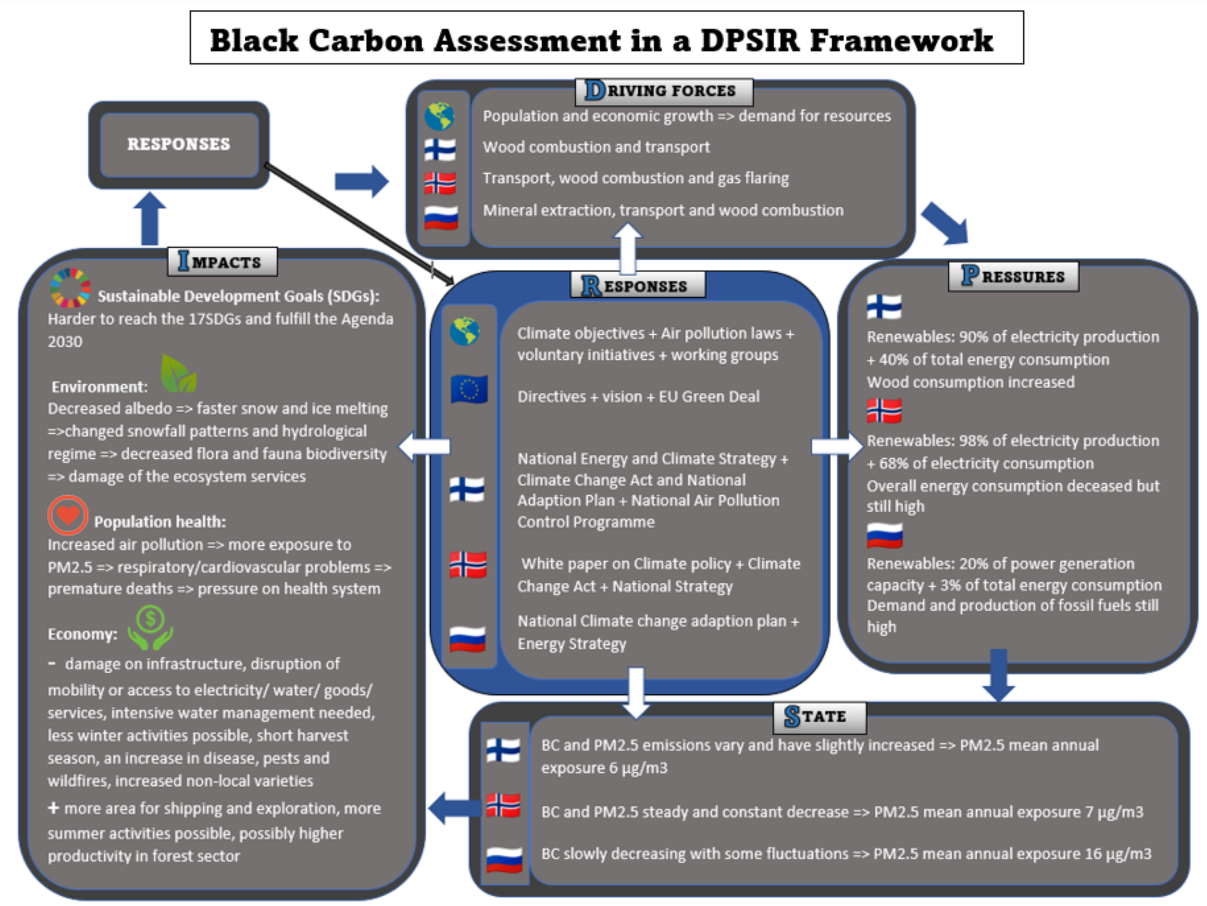


Figure 4: DPSIR (Drivers-Pressures-State-Impacts-Responses) Framework focused on Black Carbon

The literature review on the topic of Black Carbon has been summarized in Figure 4. The DPSIR Framework has previously been used to analyse inter-linkages between environmental and socio-economic factors (Maxim, Spangenberg and O'Connor, 2009). The driving forces, being the population and economic growth, and the country specific sectors result in actions that put pressure on the environment. This influences the current state of emissions and therefore impacts air quality. BC emissions are complex to evaluate or measure due to their complex interaction with climate change and air quality. The lead to a cascade of impacts on the environment, population's health and the economy. BC emissions also directly impact efforts to achieve the SDGs. That is why management through policy plays a vital role.

This framework is an interdisciplinary tool that aims to visualize the complex problem of BC. Nevertheless, this is a simplified representation of synergies between factors. A more detailed explanation is found in the previous chapters (2.1, 2.2, 2.3, 2.4).

2.6 Sustainable Development Goals

2.6.1 The concept

The 17 SDGs and 169 targets were adopted in 2015 by all 193 United Nations (UN) members, seeking to build on the Millennium Development Goals and achieve the targets before 2030 (UN, 2016).

Sustainable development was for the first time defined in Our Common future report in 1987 as ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

Figure 5: A visual representation of the Sustainable Development Goals (Schlange, Frank and Cort, 2020)

The SDG Agenda has 17 goals that focus on a world free of poverty, hunger, disease and violence. It aims to create equality and provide access to quality education, health care and social protection (Figure 5). The UN strives to create a safe and healthy environment for all, taking into consideration climate change and pollution to improve life on water and land. For the successful achievement of these objectives global collaboration is needed that all sectors. Every country must implement these targets in all industries, while taking into account the national situation and respecting the national policies and priorities (UN, 2016).

2.6.2 Connection with Black Carbon

Since BC has a direct effect on the temperature increase in the Arctic, it is a strong contributor to global warming. It can compromise the achievement of the SDGs, while mitigation measures can strengthen all 17 SDGs (Fuso Nerini *et al.*, 2019). The connection between climate change and sustainability is therefore inseparable, with multiple inter-linkages between the 2030 Agenda for Sustainable Development and the Paris Agreement (UNFCCC, 2019).

"In the bigger picture, the 2030 Agenda and the Paris Agreement are really about the same things. They provide our biggest opportunity for positive, systemic change that will ensure a resilient, productive and healthy environment for present and future generations." UN climate chief Patricia Espinosa (UNFCCC, 2019)

Through climate change, BC can have a cascade effect on different aspects of the environment, society and economy. This is a complex interaction between anthropogenic pressures and the ecosystem. Currently the overexploitation of resources and pollution contribute to habitat fragmentation and the loss of terrestrial and marine biodiversity. Furthermore, this will decrease ecosystem resilience and the provision of ecosystem services, directly affecting life on land (SDG15) and life below water (SDG14). This is also inseparable from the climate action (SDG13) that aims to reduce harmful emissions and mitigate this environmental impact.

Global warming leads to weather variability, often in the form of extreme temperatures, droughts, floods or storms. Unexpected weather conditions can damage agricultural land and affect the crops and cattle, as well as damage properties and basic provisioning infrastructure. That can pose a threat to the achievement of the SDGs due to decreasing the access to clean water and sanitation (SDG6) and increasing poverty (SDG1) and hunger (SDG2). This combined with the harmful emissions has a negative impact on human health (SDG3).

Sustainable development is a key factor in combating climate change. Emissions mitigation is important not only as part of climate action but as part of promoting innovation within the industry and infrastructure (SDG9), increasing responsible consumption and production (SDG12), creating sustainable cities (SDG11) and providing quality education (SDG4) on sustainability.

2.6.3 The Global Survey

Awareness

According to the Global Survey on Sustainability and the SDGs (funded by the Government of the Federal Republic of Germany), the concept of the SDGs is not well known with an average awareness score of less than 50% (49.7% globally, 56.5 % in EU). It was found that almost all participants know the term ,,sustainability'' but very few know the concept in depth itself. This challenges the achievement of these global goals for peace and prosperity (Schlange, Frank and Cort, 2020). Other studies such as the Eurobarometer show also that there is a gap between the awareness of the SDGs and the knowledge with only 4 in 10 aware and 1 in 10 Europeans that know what the SDGs are (European Union, 2017). However, the Youth Speak Global Report states that 45% of the youth is aware of SDGs, putting it higher than the Eurobarometer but lower than the results of the Global Survey (AIESEC, 2016).

Personal actions

When it comes to personal actions, globally more than 50% of the population considers sustainability when purchasing food. The majority of the Europeans take it also into account when buying other goods and services, and slightly less when it comes to voting and mobility. Short-term actions are chosen over long-term, creating a great opportunity for sustainable consumerism and a possibility to achieve long-term sustainable development. Furthermore, voting and political organizations can communicate the importance of sustainability and promote knowledge of the topic (Schlange, Frank and Cort, 2020).

2.6.4 Drivers of change: an interdisciplinary approach

For the successful implementation of the SDGs, the governments must lead the way, in collaboration with the private businesses, research institutions and non-governmental organizations (NGOs). The actors that contribute the most to the achievement of SDGs are the businesses and National Political actors (Schlange, Frank and Cort, 2020).

More than half of the world's population is between 15 and 24 years of age, what makes the youth the driver behind fulfilling the SDGs targets (AIESEC, 2016). Academic institutions such as universities educate the new generation to behave as responsible citizens and therefore play a major role in achieving the SDGs.

The Global Survey on Sustainability shows that the SDGs that require the most urgent action in the education system are SDG 13, SDG 12 and SDG 4 (Schlange, Frank and Cort, 2020). The higher education is directly related to SDG 4. However a quality education will be benefit the fulfilment of all the SDGs (Zamora-Polo *et al.*, 2019).

Knowledge within the educational and professional environments in different disciplines is still fragmented and needs to be integrated through interdisciplinarity, as to help students successfully understand the world's complex problems (Eagan, Cook and Joeres, 2002).

The SDGs cannot be implemented only in isolated disciplines since they are interconnected with disciplines such as geosciences, environment, agroeconomics, geography, engineering, medicine, nutrition, architecture, sociology, political science, business etc. Interdisciplinarity is needed in all aspects of the education system, as it helps to understand and act on complex problems (Defries *et al.*, 2012; Annan-Diab and Molinari, 2017). However, interdisciplinary education is challenging and different approaches have to be used in order for it to be successful (Summers, Childs and Corney, 2005).

The importance of the interdisciplinary approach, where teachers integrate the three pillars of SDGs, society, environment and economy into the curriculum have been emphasized by the United Nations Educational, Scientific and Cultural Organization (UNESCO), already in 2005 as part of the Millennium Development Goals (UNESCO, 2005). Integrating the SDGs into international and national policies on education is currently not only a main priority, but a needed governmental response to disaster management plans and low carbon strategies (UNESCO, 2014).

Zamora-Polo and Sánchez-Martín propose that sustainability should be displayed as an Integral ecology or the New Paradigm of Humans-Earth Relationship. This includes the integration of five dimensions: spiritual development, equity and global ethics, environmental awareness, development cooperation and global environmental policies. This concept should be integrated intentionally into the university's vision as to promote the ability of students to see the complexity of these dimensions through systems of thinking. This way theoretical knowledge will be processed better and positive behaviour will be promoted.

The outbreak of Covid in 2020 however has greatly impacted all students, possibly affecting the learning outcomes and social and behavioural development of children. Distance learning has been a good alternative but it has come with challenges such as the lack of good working environment and stable internet (UN, 2020).

2.7 Black Carbon and the Sustainable Development Goals within university education

UNESCO launched the Global Action Programme on Education for Sustainable Development (GAP ESD) in 2014, as well as built a platform to support sustainable development through education (Land and Mallow, 2018). This is part of the current SDGs Agenda 2030, where quality education in the form of SDG 4 plays a key role in achieving sustainable development (UNESCO, 2019).

2.7.1 Finland

Finland and circular economy

Finland is a pioneer in using the concept of bio and circular economy. It has prepared a road map with the help of the Finnish Innovation Fund Sitra that focuses on best practices to accelerate the transfer to a circular economy. A platform was created in advance, promoting knowledge of the topic to make the transition smoother (Sitra, 2020). Citizens, governmental organizations and companies from different sectors took part of the process, contributing with ideas and viewpoints to create an unique tool to best fit all needs (Sitra, 2016).

Arene and Carbon neutrality

Higher educational institutions contribute to these goals as well. All universities of applied sciences in Finland are part of Arene – The Rectors' Conference of Finnish Universities of Applied Sciences. The rector of these universities meet eight times annually to discuss important issues and propose common strategies. Some of their goals are to change the world for a better place and to work openly and responsibly (ARENE, 2021).

With the collaboration of Arene, a joint program for sustainability has been established. It is based on the SDGs and aims to achieve carbon neutrality in the member universities by 2030. The main focus is combating climate change through incorporating sustainable development in all research development and innovation (RDI) activities of the university and all degree programs.

Sustainability within the university

In order to calculate the carbon footprint and find ways to reduce it, a SDGs team was set up at LUAS. Its goals is to create an action plan by taking into consideration all education and RDI activities as to set clear goals and measures to promote sustainability through education and own actions. It is closely related with the new sustainable development program at the university that launched in 2020-2022 (Knife and Tyni, 2020).

Ville Rauhala, a research and development (R&D) manager and a member of the sustainability team was contacted for more insight on how the sustainable development team operates. The team consists of 15 members including experts in circular economy, a quality chief, director of SDGs, chief of staff, communication managers, social contacts within the student association ROTKO, development managers R&D and educators. Currently the team has set specific goals for the next 4 year with a 10 year perspective that follow the objectives of the EU Green deal. An action plan with detailed measures will soon be ready. The goal is to integrate the SDGs in all activities of the university, ranging from the education degrees to the R&D activities. It is important to make the sustainability process visible through education, R&D work and service business. Overall all SDGs are taken forward in LUAS but through a study, involving all staff members 6 specific SDGs were chosen that align with the university's strategy, expertise and goals. This survey also analysed different courses, showing that many courses and degrees already had the topic of sustainability incorporated to some extent (Lapland UAS, 2021).

The targets of LUAS are separated into four main themes according to Knife and Tyni:

1) Organization of sustainable work
   The creation of a well-established network and communication throughout the organizations plays a major role. The current state evaluation will determine the measures that need to be taken. This is an important step that determines the future objectives for the next four years and focuses on achieving sustainability long-term.
2) Real estate
   The energy consumption was evaluated, based on polytechnic properties as to determine the current state. There was a lack of data for the heat consumption that resulted in realistic readings only from 2018. The results showed that heating and electricity were the biggest emitters of carbon dioxide within the university. There has already been a transition to green electricity, generated by hydropower. However, follow-up measures are yet to be published.
3) Restaurants and food

Food waste is being monitored in the Rovaniemi and Kemi campuses by a working group, aiming to minimize food waste. Covid has caused the closing of student restaurants and has therefore impacted data collection. Measures have already been taken such as providing a vegetarian dish as first option in the menu. The biggest challenge observed however, was the distance learning and the constantly changing number of students on campus. This makes planning of food quantity difficult, therefore possibly leading to food waste.

4) Communication and events
Visual communication tools play a major role when getting messages across to people from different countries and cultures, as well as staff and students within the organization. This sustainable aspects and communication are also part of all event planning and extra activities.

Overall LUAS has incorporated the SDGs very well into its education system. Many courses already include the topic of sustainability. Teachers are themselves responsible for creating their own curriculum, therefore being the core of the sustainability initiatives. Currently, the sustainable development group is communicating with the educators and evaluating where the SDGs can further be used within the courses and activities (Lapland UAS, 2021).

As to obtain better insight into different degrees, Anu Harju-Myllyaho from Tourism, Heikki Konttaniemi from ICT Engineering and Anne-Mari Väisänen from Forest Engineering were contacted. They only confirmed previous findings that LUAS is already quite sustainable and that the SDGs are being integrated in all activities and projects possible. The topic of Black Carbon however, was found to be more specific and is only integrated in topic related degrees (Harju-Myllyaho, 2021; Konttaniemi, 2021; Väisänen, 2021).

The tourism degrees for example are multidimensional and incorporate the political and social aspects of sustainability in projects already (Harju-Myllyaho, 2021). They also revolve around the importance of the welfare of animals within farms (Lapland UAS, 2018). In Forest Engineering, the main theme is circular economy, with many more related themes included in projects such as green care and wellbeing, renewable energy and innovations (Väisänen, 2021). Within the ICT Engineering, ethical skills and the principles of sustainable development play a major role in the new curriculum in the Finnish education (LUAS, 2021a) and the new upcoming English course (LUAS, 2021b). Sustainability is incorporated into a Finnish project in the second year of the studies, revolving around the topic of circular economy (Konttaniemi, 2021). Furthermore, energy efficiency and innovative sustainable solutions are taken into consideration in R&D projects such as the developing of robots or virtual reality solutions (FrostBit, 2021; Konttaniemi, 2021).

2.7.2 Norway

Norway and circular economy

Norway has implemented policies on energy efficiency and consumption that promote sustainability. It is a world leader in reducing emissions through renewable energy for electricity and the use of electric cars. It greatly contributes to reducing world deforestation through the International Climate and Forest Initiative and donations to the Green Climate Fund. The country however still has a long way to go when it comes to reducing emissions from fossil fuel extraction (Earth5R, 2020).
Oslo has received the award European Green Capital for 2019, where green mobility and innovation were the leading factors. It also aims to become carbon neutral by 2050.

SDGs in higher education

In 2018, Norway formed the National Committee for Agenda 2030 in the Higher Education Sector. Followed by that, the University of Bergen (UiB) attained an official hub status for the SDG14, Life below water (University of Bergen, 2021). UiB is the first university in the country to officially take on the SDGs 2030 Agenda. SDG Bergen is an initiative that encourages researchers to work together with policy makers. This led to the Conference Bergen on the SDGs in 2018, bringing together global knowledge and engaging Norwegian universities such as The Arctic University of Norway (UiT). The SDG Bergen Task Force was also created to act as a bridge between the science and the policy (Nguyen, 2019).
Furthermore, UiT realizes the importance of its location and has therefore specialized its research in polar environment, climate, biology and fishery science (Times Higher Education, 2021). Also, a new project called BRIDGES has started where UiT is involved. It aims to increase interdisciplinary between school subjects and promote knowledge among the teachers. A new National Curriculum has been implemented since August 2020 where sustainable development is among one of the main themes (Didham, 2021; USN, 2021). Even though the focus lies on the teachers, this will also then have a great impact on how students learn to see the complexity of environmental problems.

2.7.3 Murmansk

Russia and circular economy

The national portal Climate Russia aims to strengthen communication on environmental problems and share current initiatives with citizens, experts, businesses and governments. It promotes sustainable technology and best practises, and unites partners to act together on sustainable development (Climate Russia, 2015). Furthermore, Russia is in the process of transitioning to a sustainable economy, including the SDGs into national projects and programs. As of 2020, the Agenda 2030 has been officially approved by the president and adjustments have been made (Analytical Center for the government of the Russian Federation, 2020). Previously, strategies of circular economy are already in place. However, according to Gutman and Teslya, there is a lack of unified and integrated strategy that makes the monitoring of developments in the field very hard. A well-developed strategy focused on sustainability will be crucial in regions such as Murmansk, where the lack of measures can cause huge impacts on the Arctic (Ivanova and Dyachenko, 2020). Murmansk Region has taken initiatives to reduce emissions such as upgrading transport vehicles or choosing to use best practises for mining activities (ACAP, 2017).

SDGs in higher education

The educational system supports the planting of oaks, currently in decline in the wild through forestry students (Climate Russia, 2015). The first university to truly develop a sustainability strategy was Moscow State University of International Relations (MGIMO). The university focuses on incorporation sustainable development into all its activities. The focus lies on reducing GHG emissions through increasing energy efficiency, improving waste management and improving transport practises, as well as creating more transdisciplinary educational programs. The development of this strategy is based on international strategies of other leading universities (Climate Russia, 2015). Murmansk State Technical University (MSTU) is a leading research institution with the development priorities of marine technologies, Arctic bioresources, Arctic mineral and hydrocarbon resources and logistics (Arctic, 2021). There was however limited information available on the university’s involvement with sustainability.

3 Methodology

3.1 Literature study

A descriptive literature study was conducted, as to give an overview of the main topic of the project - Black Carbon and the main topic of the survey - SDGs. In the first part, information on Black Carbon was used to create a DPSIR framework diagram, where the drivers, pressures, state, impacts and responses were described. In the second part, the importance of the 2030 Agenda and the SDGs was described. The SDGs were linked with BC, focusing on the importance of integration of these topics within the higher education system.

As to get a better insight into the integration of SDGs, the head of different departments within the universities were contacted through email. They were invited for a short interview or were asked to answer questions per email. Within LUAS, the R&D manager of the new SDGs team was contacted for additional information.

Where possible information from Finland, Norway and Russia was mentioned. The focus however was on Finland and the leading university (LUAS) that can make greater use of the results from the survey due to its strong involvement in the 2030 Agenda.

Different search engines were used under which Google Scholar, Research Gate and Elsevier. Peer-reviewed scientific articles and official rapports were used, where possible from the last 5-6 years.

3.2 Survey

The questionnaire aimed to investigate if there is a gap of knowledge among the educators and the youth. It aimed at students and teachers from the partner universities within the regions of Lapland (LUAS), Troms (Uit) and Murmansk (MSTU). The importance of the SDGs was emphasized since it was assumed that a lack of knowledge of this topic will likely result in a lack of knowledge of BC. Relevant questions for creating a roadmap such as what is the current status, where do we want to go, how will we achieve this, what should we do and when should we act were incorporated into the survey.

The survey questions were chosen, based on the different stages of roadmap creation. They were reviewed before sending to participants by the mentors of this thesis. It was aimed for a minimum response of 60 students and 60 teachers per country.

The survey was created with Google Forms at the beginning of March 2021 and consisted of 30 questions. It was made up of different sections to give a better structure to the participants and to ease data analysis. The first part focused on general questions that helped put participants into groups. The next parts assessed the knowledge of the SDGs and BC. The next parts collected opinions on the educational system and governmental practises, as well as attitudes and suggestions on future improvements. Most questions were multiple choice, but some were yes/no questions and a few were open for suggestions and ideas. There were separate forms for students and teachers, as well as for each country. In Russia, the survey was distributed in Russian as to increase response rate. The question on income was calculated in different currency, depending on the country. The value was however always roughly the same so that it could be used for analysis.

It was always aimed for full transparency. The data collection was however narrowed to the partner universities that were within the study regions. The survey was voluntary and asked for consent to use the data for research purposes. The privacy and confidentiality of each participant was assured, where no name is or other sensible personal information was asked. Misleading information and unclear questions were avoided.

The survey was sent primarily through email to the project partners and international coordinators within each university. As to generate a greater response a lottery to win a chocolate box was made. The first communication consisted of an email, motivating people to take action and help to contribute to the project. Two weeks after the initial sent date, a new email was sent that explained the importance of the project and urged students and teachers to answer. The emails were focused on participants from the Environmental, Tourism and Engineering sector but asked for everyone to answer. Other communication channels such as Linkedin and Facebook were also used, as well as the partner contacts within each university. As to increase the number of participants, closer to the end of the data collection emails were sent to professors within each university. Data collection took place between 15 March and 26 April.

The questionnaire aimed to evaluate the status of knowledge of BC and the SDGs in universities within the regions of Lapland, Troms and Murmansk. The data collection resulted in 307 student and 34 teacher answers. The biggest number of results came from Finland (291 students and 19 teachers), followed by Norway (13 teachers, 10 students) and Russia (2 teachers, 6 students). Results that compared the knowledge of BC and the SDGs between countries was therefore biased due to the uneven response rate. Analysis that took data from all three countries represented mainly the situation in Finland.

The responses were used to investigate if there is a difference in the level of knowledge of BC and the SDGs between the regions, students and teachers, genders, age groups, sectors, years of involvement in university and income. The main information channels on BC and the SDGs were also described within the teachers and students. Information was also collected on personal attitudes, opinions on governmental and university practises and suggestions.

The statistical software SPSS was used to conduct separate analysis per variable. Students and teachers were mostly analysed apart, except when knowledge of the topics between the countries was compared. Given that the variables were nominal or ordinal and often had more than two categories, the non-parametric Kruskal-Wallis test was to investigate if there were significant differences between groups. For this purpose the hypothesis was tested based on the p value, evaluated according to an alfa level of 5%. This means that if a p value under 5% was observed, it was concluded with 95% certainty that there is a statistically significant difference between groups. When the dataset was small however, the p value used was more conservative. Analysis among the teachers used the Fischer’s exact test, suitable for a small dataset. When a significant difference was found, Mann Whitney U tests were performed as post hoc to test two per two differences between the group categories. To reduce Type I error (a higher chance of getting a false positive), a Bonferroni correction was used. The alfa value was then divided by the number of comparisons to make analysis more conservative. This was however then prone to a Type II error (failing to find a difference).

Per research question, a separate analysis was conducted. Whether there is a difference or not, the results from SPSS were presented in the form of a table as a screenshot so that space was used efficiently. An exception was made when a post hoc test was conducted, where only the categories that were statistically different were presented. The result from the rest were only described. There was some visual representation in the form of bar graphs but statistical analysis in the form of tables was predominant.

4 Results

4.1 Participation

The response rate was based on the answers from the students and teachers, divided by the total number of teachers and academic staff (UArctic, 2021). This resulted in a teacher response rate of 0,05 (5%) in Finland, 0,008 (0,8%) in Norway and 0,005 (0,05%) in Russia. The last one was calculated, based on only one response, since the second answer was found to be a test trial. The student response rate was 0,07 (7%) in Finland, 0,0006 (0,06%) in Norway and 0,003 (0,3%) in Russia.

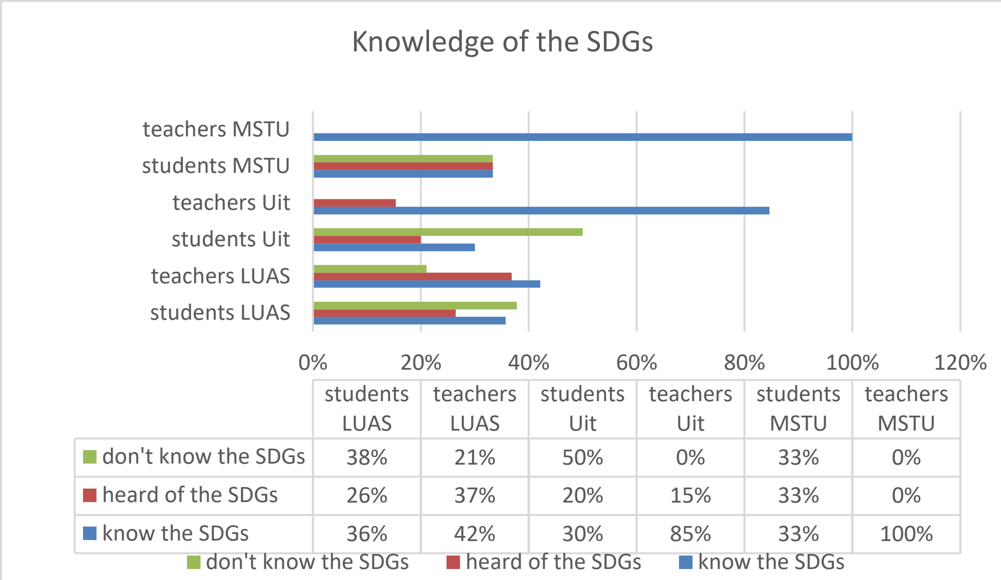
In total there were 341 participants, of which 149 male (44%), 184 female (54%) and 8 (2%) that preferred not to answer. This are results from the total of 307 student and 34 teacher participants. From Finland, 19 teachers (6 male,12 female) and 291 students (125 male, 160 female) took part. There were 13 teachers (6 male, 7 female) and 10 students from Norway (6 male, 4 female) and 2 teachers (both male) and 6 students (1 male, 1 female) from Russia. With most results coming from Finland, analysis where all countries were taken into account reflected mostly the situation in Finland. Representation per country was carefully evaluated due to possible bias from the uneven response rate. The group that preferred not to mention their gender was often not mentioned in analysis that aimed to evaluate differences between genders. Also when a country was mentioned in the results, the data refers to the university within the country. Within Finland this was Lapland University for Applied Sciences (LUAS), within Norway Uit the Arctic University of Norway (Uit) and within Russia Murmansk State Technical University (MSTU).

4.2 Differences of knowledge of the Sustainable Development Goals and Black Carbon

The knowledge of the SDGs and BC had three levels that corresponded to the answers from the survey (know the topic, heard of the topic and don’t know the topic). To answer the research questions, an apart statistical analysis was conducted on the level of knowledge between universities, genders, age groups, sectors, years of involvement in university and income.
It was important to note that the highest response came from Finland, followed by Norway and Russia (4.1). Also, a higher mean value was connected to more answers from category 3 (don’t know the topic). This was because the order of the knowledge reflected the order of the answers from the survey (1= know the topic, 2 = heard of the topic; 3 = don’t know the topic).

Differences of knowledge across universities

The three levels knowledge of the SDGs and BC were compared between LUAS, Uit and MSTU. The responses were used to analyze data across universities, where the teachers and students within each one were represented apart as a percentage of the total number of participants in that group and within the organization. For this research question, analysis was also conducted to investigate if there was a difference in knowledge between the countries, combining the data of the teachers and students together.

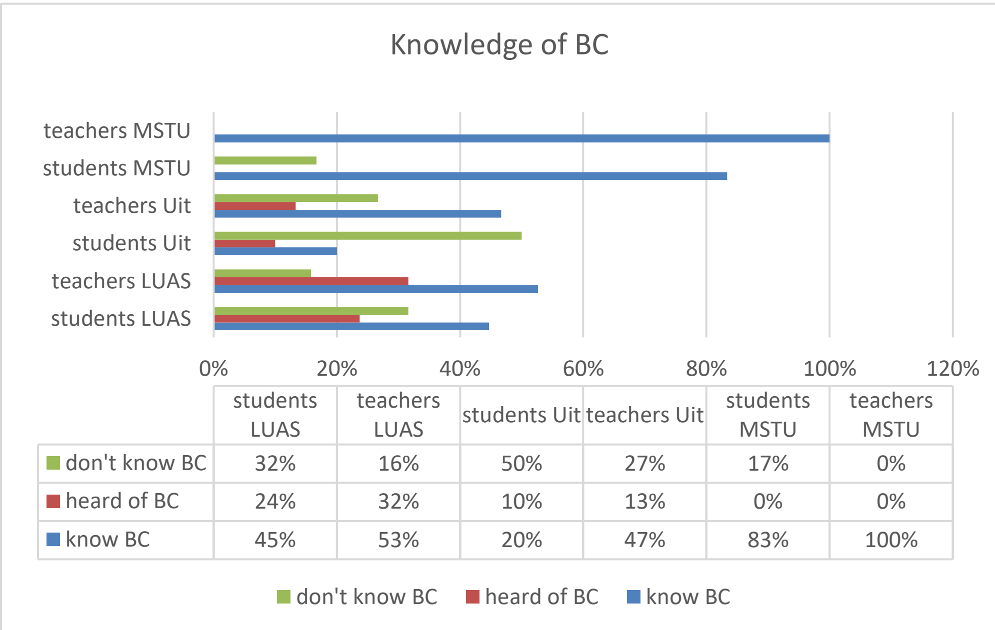


	students LUAS	teachers LUAS	students Uit	teachers Uit	students MSTU	teachers MSTU
don't know the SDGs	38%	21%	50%	0%	33%	0%
heard of the SDGs	26%	37%	20%	15%	33%	0%
know the SDGs	36%	42%	30%	85%	33%	100%

Figure 6: Knowledge of the Sustainable Development Goals among teachers and students per university (% calculated from the total answers within the group of students and teachers within each university apart)

Figure 6 gives an overview of the responses of the level of knowledge of the SDGs per university. In MSTU all teachers that answered knew the SDGs. The response from the students however was mixed, with equal numbers in each category. In Uit, most teachers knew the SDGs (85%). Half of the students however did not know them, only 20% had heard of them and only 30% really knew the topic. In LUAS, the results were more varied. There, only 42% of teachers knew the SDGs, 37% had heard of them and only 21% did not know them. Also, 38% of the students never heard of the SDGs, 26% had and 36% actually knew them.

Overall, in all three universities there are more teachers that knew the SDGs than students. From the results, it seemed that teachers in Russia and Norway had more knowledge of this topic, while this is not true for students. Finnish students seemed to have the highest knowledge.



	students LUAS	teachers LUAS	students Uit	teachers Uit	students MSTU	teachers MSTU
don't know BC	32%	16%	50%	27%	17%	0%
heard of BC	24%	32%	10%	13%	0%	0%
know BC	45%	53%	20%	47%	83%	100%

Figure 7: Knowledge of Black Carbon among teachers and students per university (% calculated from the total answers within the group of students and teachers within each university apart)

When the results from the knowledge of BC were graphically represented, it looked like once again the teachers that took part from Russia had the highest knowledge of the topic. The second highest is Finland, followed by Norway. When it came to the students, exactly the same trend followed (Figure 7).

To Investigate if the graphical interpretation is correct, statistical tests followed that aimed to find statistically significant differences between the groups.

Kruskall-Wallis Test

	Country	N	Mean Rank
KnowledgeSDGs	Finland	19	21,05
	Norway	13	13,31
	Russia	2	11,00
	Total	34	
KnowledgeBC	Finland	19	17,58
	Norway	13	18,54
	Russia	2	10,00
	Total	34	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	7,484	1,587
df	2	2
Asymp. Sig.	,024	,452

a. Kruskal Wallis Test

b. Grouping Variable: Country

H0: There is no significant difference in the level of knowledge of the SDGs between countries among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs between countries among the teachers
P value = 0,024 = 2% < 5%
=> There is a significant difference in the level of knowledge of the SDGs across between countries

H0: There is no significant difference in the level of knowledge of BC between countries among the teachers
H1: There is a significant difference in the level of knowledge of BC across between countries among the teachers
P value = 0,452 = 45% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC between countries

Figure 8: Statistical tests on the difference in knowledge of the Sustainable Development Goals and Black Carbon between countries among the teachers

Mann-Whitney Test

	Country	N	Mean Rank	Sum of Ranks
KnowledgeSDGs	Finland	19	19,47	370,00
	Norway	13	12,15	158,00
	Total	32		

Test Statistics[a]

	KnowledgeSDGs
Mann-Whitney U	67,000
Wilcoxon W	158,000
Z	-2,475
Asymp. Sig. (2-tailed)	,013
Exact Sig. [2*(1-tailed Sig.)]	,030[b]

a. Grouping Variable: Country

b. Not corrected for ties.

H0: There is no significant difference in the level of knowledge of the SDGs between Finland and Norway among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs between Finland and Norway among the teachers
P value = 0,03 = 3% > 1,6% (Bonferroni adjusted alfa value)
=> There is no significant difference in the level of knowledge of the SDGs between Finland and Norway

Figure 9: Post hoc test on the knowledge of the Sustainable Development Goals between Finland and Norway among the teachers

When the responses from the teachers were analyzed, there was no statistically significant difference found in the level of knowledge of BC between the three countries (p = 0,452). There was however a statistically significant difference in the level of knowledge of the SDGs (p = 0,024< 0,05) (Figure 8). This just meant that there was a difference somewhere between Finland, Norway and Russia. In order to investigate where the difference was, three post hoc tests were conducted between Finland-Norway, Finland-Russia, Norway-Russia.

The initially suspected difference among the teachers, turned out to be between Finland and Norway (Figure 9). Because there were three comparisons however, the alfa value was adjusted to 1,6%. Due to the small dataset, the Fisher's exact p value was used (p = 0,03). In this case it meant that the difference was not significant. Finland had a higher mean value than Norway, meaning that it scored higher. Here, only the post hoc comparison with possible significance was included. The post hoc comparison Finland and Russia resulted in a p value of 0,24 and the one between Norway and Russia in a p value of 0,8.

Kruskal-Wallis Test

	Country	N	Mean Rank
KnowledgeSDGs	Finland	291	153,25
	Norway	10	162,15
	Russia	6	177,00
	Total	307	
KnowledgeBC	Finland	291	152,82
	Norway	8	199,13
	Russia	6	100,25
	Total	305	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	,566	5,018
df	2	2
Asymp. Sig.	,754	,081

a. Kruskal Wallis Test

b. Grouping Variable: Country

H0: There is no significant difference in the level of knowledge of the SDGs between countries among the students
H1: There is a significant difference in the level of knowledge of the SDGs between countries among the students
P value = 0,754 = 75% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs between countries

H0: There is no significant difference in the level of knowledge of BC between countries among the students
H1: There is a significant difference in the level of knowledge of BC between countries among the students
P value = 0,081 = 8% > 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC between countries

Figure 10: Statistical test on the difference in knowledge of the Sustainable Development Goals and Black Carbon between countries among the students

When the student data was analyzed, there was no statistical significant difference found in the level of knowledge of the SDGs or BC between the countries. The p value for the SDGs analysis observed was 0,754 and for BC, 0,081 (Figure 10).

A third statistical test focused on all participants, combining the teachers and students. It had the same goals as the previous two tests, but aimed to deliver results on a broader scope.

Kruskal-Wallis Test

	Country	N	Mean Rank
KnowledgeSDGs	Finland	310	174,49
	Norway	23	124,89
	Russia	8	168,25
	Total	341	
KnowledgeBC	Finland	310	170,70
	Norway	21	184,57
	Russia	8	104,56
	Total	339	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	6,038	4,702
df	2	2
Asymp. Sig.	,049	,095

a. Kruskal Wallis Test

b. Grouping Variable: Country

H0 There is no significant difference in the level of knowledge of the SDGs between countries
H1 There is a significant difference in the level of knowledge of the SDGs between countries
P value = 0,049 = 4,5% < 5%
=> There is possibly a significant difference in the level of knowledge of the SDGs between countries => post hoc needed

H0: There is no significant difference in the level of knowledge of BC between countries
H1: There is a significant difference in the level of knowledge of BC between countries
P value = 0,095 = 9,5% > 5%
=> There is no significant difference in the level of knowledge of BC between countries

Figure 11: Statistical test on the difference in knowledge of the Sustainable Development Goals and Black Carbon between countries among the students

Mann-Whitney Test

	Country	N	Mean Rank	Sum of Ranks
KnowledgeSDGs	Finland	310	170,36	52811,50
	Norway	23	121,72	2799,50
	Total	333		

Test Statistics[a]

	KnowledgeSDGs
Mann-Whitney U	2523,500
Wilcoxon W	2799,500
Z	-2,466
Asymp. Sig. (2-tailed)	,014

a. Grouping Variable: Country

H0: There is no significant difference in the level of knowledge of the SDGs between Finland and Norway
H1: There is a significant difference in the level of knowledge of the SDGs between Finland and Norway
P value = 0,014 = 1,4% < 1,6% Bonferroni adjusted p value
=> There is a significant difference in the level of knowledge of the SDGs between Finland and Norway

Figure 12: Post hoc test on the knowledge of the Sustainable Development Goals between countries among all participants

There was no difference in the level of knowledge of BC found between the countries (p = 0,095). When the knowledge of the SDGs was observed however, there was a statistically significant difference found (p = 0,049) (Figure 11). Through a post hoc test was found that the difference lied between Finland and Norway (p = 0,14) (Figure 12). The other two comparisons Finland-Russia (p = 0,866) and Norway- Russia (p = 0,411) showed no statistical significance.

Differences in knowledge between teachers and students

To analyse if there was a statistically significant difference in the level of knowledge of the SDGs and BC between the teachers and students, the combined data from all three countries was used.

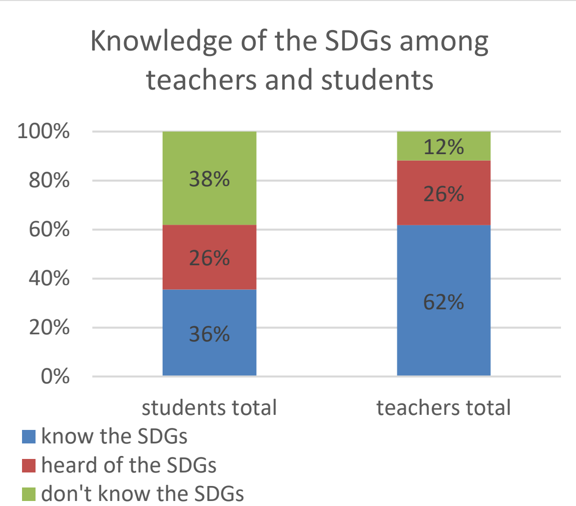


Figure 13: Knowledge of the Sustainable Development Goals among total teacher and student participants

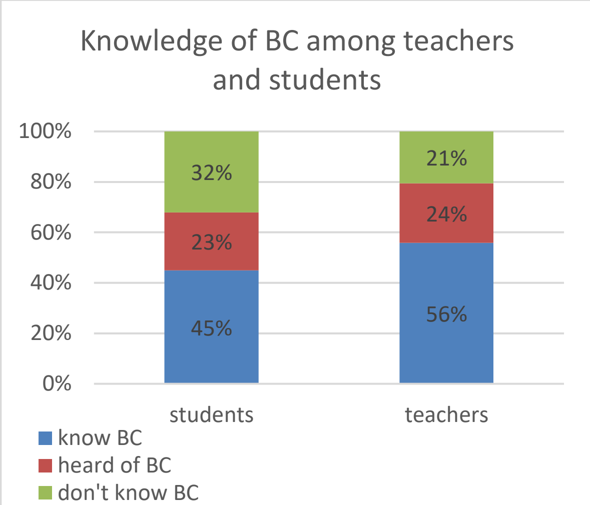


Figure 14: Knowledge of Black Carbon among the total teacher and student participants

The level of knowledge of the SDGs and BC was graphically represented among teachers and students (Figure 13; Figure 13: Knowledge of the Sustainable Development Figure 14: Knowledge of Black Carbon among the total Goals among total teacher and student participants teacher and student participants).
The teachers had almost twice as high score on the knowledge of the SDGs, with 62% of them that knew the topic in comparison to 36% of students. Only 12% of the teachers didn't know the SDGs, while almost three times (38%) more students were not aware of it.
When it came to the knowledge of BC, the difference between teachers and students was more subtle. 56% of teachers and 45% of students answered that they knew BC; while 21% teachers and 32% students did not know it.

For a better overview of the knowledge of the SDGs and BC, answers to additional questions were included in the results.

On the free choice question, regarding how many SDGs dis the participant know, there were 58 responses from students and 19 from teachers. From these answers, 45% of students knew between 1 and 6 SDGs, 33% between 7 and 12 and 22% between 12 and all 17 SDGs. From the teachers that answered, 26% knew 6 or less SDGs, 42% knew between 7 and 12 and 21% knew 12 or more. The words students and teachers most often related with the SDGs were environment, equality, climate action, health, sustainability and green energy.

The most common words students and teachers associated with BC were health issues, global warming, pollution and environmental problems. When it came to a more in depth understanding of the health effects of BC, both students and teachers had similar knowledge of the health problems, related to BC. The only difference was that students assumed more often that BC causes headaches than teachers. The trends were the same, with most participants relating BC to respiratory and cardiovascular issues. Furthermore, looking closer at the sources of BC, both students and teachers associated transport and wood burning as the main causes of emissions.

Table 5: Health problems that teachers and students associated with Black Carbon

Health problems associated with BC	Cardiovascular issues	Headaches	Respiratory problems	Eye problems	Do not know
Teachers	32%	18%	35%	24%	9%
Students	66%	52%	72%	39%	18%

Table 6: Sources of emissions that teachers and students associated with Black Carbon

Sources of emissions associated with BC	Mining activities	Maritime shipping	Transport	Wood combustion	Do not know
Teachers	11%	5%	53%	26%	5%
Students	13%	12%	51%	17%	6%

To analyse if there is a significant difference in the level of knowledge of the SDGs and BC between the students and teachers, statistical tests were conducted.

Kruskal-Wallis Test

	GroupParticipants	N	Mean Rank
KnowledgeSDGs	students	307	178,86
	teachers	34	100,03
	Total	341	
KnowledgeBC	students	305	172,35
	teachers	34	148,96
	Total	339	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	21,777	2,024
df	1	1
Asymp. Sig.	,000003	,155

a. Kruskal Wallis Test

b. Grouping Variable: GroupParticipants

H0: There is no significant difference in the level of knowledge of the SDGs between students and teachers
H1: There is a significant difference in the level of knowledge of the SDGs between students and teachers
P value = 0,000003 = 0,003% <<< 5%
=> There is a significant difference in the level of knowledge of the SDGs between students and teachers

H0: There is no significant difference in the level of knowledge of BC between students and teachers
H1: There is a significant difference in the level of knowledge of BC between students and teachers
P value = 0,155 = 16% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across between students and teachers

Figure 15: Knowledge of the Sustainable Development Goals and Black Carbon among the total teacher and student participants

There was a strong statistically significant difference found in the level of knowledge of the SDGs among teachers and students (p = 0,000003). A lower mean value for the teachers showed that they had more answers from category 1 (know the SDGs). Teachers had therefore a better understanding of the topic (Figure 15). When it came to BC, there were no significant differences found (p = 0,155).

Differences in knowledge between genders

There were statistical tests conducted to analyse if there was a difference in the level of knowledge of the SDGs between genders among the teacher and student participants. The participants that did not reveal their gender were not taken in the analyses that follow since they are focused on differences between male and female participants.

Kruskal-Wallis Test

	Gender	N	Mean Rank
KnowledgeSDGs	Male	14	17,86
	Female	19	16,37
	Total	33	
KnowledgeBC	Male	14	17,57
	Female	19	16,58
	Total	33	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	,265	,107
df	1	1
Asymp. Sig.	,607	,743

a. Kruskal Wallis Test

b. Grouping Variable: Gender

H0: There is no significant difference in the level of knowledge of the SDGs across gender categories among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs across gender categories among the teachers
P value = 0,607 = 61% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across gender categories

H0: There is no significant difference in the level of knowledge of BC across gender categories among the teachers
H1: There is a significant difference in the level of knowledge of BC across gender categories among the teachers
P value = 0,743 = 74% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across gender categories

Figure 16: Knowledge of the Sustainable Development Goals and Black Carbon between genders among teacher participants

There were no statistically significant differences found in the level of knowledge of the SDGs (p = 607) or BC (p = 743) among the teachers (Figure 16).

Kruskal-Wallis Test

	Gender	N	Mean Rank
KnowledgeSDGs	male	135	154,20
	female	165	147,47
	Total	300	
KnowledgeBC	male	134	150,46
	female	164	148,72
	Total	298	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	,498	,035
df	1	1
Asymp. Sig.	,480	,852

a. Kruskal Wallis Test

b. Grouping Variable: Gender

H0: There is no significant difference in the level of knowledge of the SDGs across gender categories among the students
H1: There is a significant difference in the level of knowledge of the SDGs across gender categories among the students
P value = 0,48 = 48% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across gender categories

H0: There is no significant difference in the level of knowledge of BC across gender categories among the students
H1: There is a significant difference in the level of knowledge of BC across gender categories among the students
P value = 0,852 = 85% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across gender categories

Figure 17: Knowledge of the Sustainable Development Goals and Black Carbon between genders among student participants

When the student responses were analyzed, there were also no statistically significant differences found in the level of knowledge of the SDGs (p = 0,480) or BC (p = 0,852) among male and female participants (Figure 17).

Differences in knowledge across age groups

Statistical tests were conducted apart for teachers and students in order to investigate if there were differences between the age groups. Teacher participants were divided into four age groups (21-30 years, 31-40 years, 41-50 years, +50years) and the students into three groups (18-22 years, 23-30 years, +30 years).

Kruskal-Wallis Test

	Age	N	Mean Rank
KnowledgeSDGs	21-30 years	2	18,50
	31-40 years	8	17,44
	41-50 years	7	18,36
	+50 years	17	17,06
	Total	34	
KnowledgeBC	21-30 years	2	10,00
	31-40 years	8	15,06
	41-50 years	7	22,86
	+50 years	17	17,32
	Total	34	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	,142	4,531
df	3	3
Asymp. Sig.	,986	,210

a. Kruskal Wallis Test

b. Grouping Variable: Age

H0: There is no significant difference in the level of knowledge of the SDGs across age categories among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs across age categories among the teachers
P value = 0,986 = 99% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across age categories

H0: There is no significant difference in the level of knowledge of BC across age categories among the teachers
H1: There is a significant difference in the level of knowledge of BC across age categories among the teachers
P value = 0,21 = 21% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across age categories

Figure 18: Knowledge of the Sustainable Development Goals and Black Carbon across age groups among teachers

Among the teacher participants, there were no statistically significant differences observed in the knowledge of the SDGs (p = 0,986) or BC (p = 0,210) across the age groups (Figure 18).

Kruskal-Wallis Test

	Age	N	Mean Rank
KnowledgeSDGs	18-22 years	74	153,80
	23-30 years	98	160,20
	+30 years	135	149,61
	Total	307	
KnowledgeBC	18-22 years	74	157,70
	23-30 years	96	156,09
	+30 years	135	148,22
	Total	305	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	,901	,839
df	2	2
Asymp. Sig.	,637	,657

a. Kruskal Wallis Test

b. Grouping Variable: Age

H0: There is no significant difference in the level of knowledge of the SDGs across age categories among the students
H1: There is a significant difference in the level of knowledge of BC across age categories among the students
P value = 0,637 = 64% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across age categories

H0: There is no significant difference in the level of knowledge of BC across age categories among the students
H1: There is a significant difference in the level of knowledge of BC across age categories among the students
P value = 0,21 = 21% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across age categories

Figure 19: Knowledge of the Sustainable Development Goals and Black Carbon across age groups among students

Among the student participants, there were also no statistically significant differences found in the level of knowledge of the SDGs (p = 0,637) or BC (p = 0,657) (Figure 19).

Differences in knowledge across educational sectors

The answers of the participants were grouped into the most common work and study sectors (Environment, Tourism, Engineering, Business, IT). The rest of the sectors were grouped together. The same groups were used for conducting statistical analysis among the teachers and students to evaluate if there were any significant difference in the knowledge of the SDGs and BC across the sectors.

Kruskal-Wallis Test

Ranks

	Sector	N	Mean Rank
KnowledgeSDGs	Environment	8	14,75
	Tourism	3	16,00
	Engineering	7	19,29
	Business	6	22,08
	IT	1	11,00
	Other	9	16,72
	Total	34	
KnowledgeBC	Environment	8	13,38
	Tourism	3	21,50
	Engineering	7	13,86
	Business	6	19,25
	IT	1	10,00
	Other	9	22,33
	Total	34	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	3,565	7,044
df	5	5
Asymp. Sig.	,614	,217

a. Kruskal Wallis Test

b. Grouping Variable: Sector

H0: There is no significant difference in the level of knowledge of BC across sector categories among the teachers
H1: There is a significant difference in the level of knowlegd eof BC across sector categoris among the teachers
P value = 0,217 = 22% > 5%
=>There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across sector categories

H0: There is no significant difference in the level of knowledge of the SDGs across sector categories among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs across sector categories among the teachers
P value = 0,614 = 61% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across sector categories

Figure 20: Knowledge of the Sustainable Development Goals and Black Carbon across work sectors among teachers

Kruskal-Wallis Test

Ranks

	Sector	N	Mean Rank
KnowledgeSDGs	Environment	21	137,67
	Tourism	54	141,93
	Engineering	99	159,08
	Business	41	146,83
	IT	18	144,94
	Other	73	164,90
	Total	306	
KnowledgeBC	Environment	21	132,29
	Tourism	53	152,35
	Engineering	98	145,90
	Business	41	151,50
	IT	18	175,11
	Other	73	162,27
	Total	304	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	4,010	4,353
df	5	5
Asymp. Sig.	,548	,500

a. Kruskal Wallis Test

b. Grouping Variable: Sector

H0: There is no significant difference in the level of knowledge of BC across sector categories among the students
H1: There is a significant difference in the level of knowledge of BC across sector categories among the students
P value = 0,5 = 50% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across sector categories

H0: There is no significant difference in the level of knowledge of the SDGs across sector categories among the students
H1: There is a significant difference in the level of knowledge of the SDGs across sector categories among the studentss
P value = 0,548 = 55% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across sector categories

Figure 21: Knowledge of the Sustainable Development Goals and Black Carbon across study sectors among students

There were no statistically significant differences found in the level of knowledge of the SDGs across the sectors among the teachers (p = 0,614) or among the students (p = 0,548). The same outcome was observed in analysis on the level of knowledge of BC (teachers p = 0,217; students p = 0,5) (Figure 20; Figure 21).

Differences in knowledge across years of involvement in university education

The years of involvement into university education were grouped differently for the teachers than for the students. Teachers were grouped into five categories (1-5 years, 6-10 years, 11-15 years, 15-20 years and +20 years), whereas the students were grouped according to the number of their study year (1st, 2nd, 3rd, 4th, 5th year of study). Knowledge of the SDGs and BC was compared across these categories.

Kruskal-Wallis Test

	YearsOfWork	N	Mean Rank
KnowledgeSDGs	1-5 years	9	20,06
	6-10 years	7	19,29
	11-15 years	3	26,00
	15-20 years	7	14,07
	+20 years	8	12,88
	Total	34	
KnowledgeBC	1-5 years	9	16,83
	6-10 years	7	18,79
	11-15 years	3	17,00
	15-20 years	7	17,93
	+20 years	8	16,94
	Total	34	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	7,463	,252
df	4	4
Asymp. Sig.	,113	,993

a. Kruskal Wallis Test

b. Grouping Variable: YearsOfWork

H0: There is no significant difference in the level of knowledge of BC across work years among the teachers
H1: There is a significant difference in the level of knowledge of BC across work years among the teachers
P value = 0,993 = 99% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across work years

H0: There is no significant difference in the level of knowledge of the SDGs across work years among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs across work years among the teachers
P value = 0,113 = 11% > 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across work years

Figure 22: Knowledge of the Sustainable Development Goals and Black Carbon across work years among teachers

When the knowledge of the SDGs and BC across work years of teachers was analyzed, there were no statistically significant differences found across the groups. A p value of 0,113 was observed for the SDGs analysis and of 0,993 for BC (Figure 22).

Kruskal-Wallis Test

	YearOf Study	N	Mean Rank
KnowledgeSDGs	1st year	104	152,26
	2nd year	76	141,34
	3rd year	82	153,60
	4th year	34	179,49
	5th year	11	182,18
	Total	307	
KnowledgeBC	1st year	103	153,76
	2nd year	76	146,17
	3rd year	82	156,53
	4th year	34	160,10
	5th year	10	144,00
	Total	305	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	6,121	1,064
df	4	4
Asymp. Sig.	,190	,900

a. Kruskal Wallis Test

b. Grouping Variable: YearOf Study

H0: There is no significant difference in the level of knowledge of BC across study years among the students
H1: There is a significant difference in the level of knowledge of BC across study years among the students
P value = 0,9 = 90% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across study years

H0: There is no significant difference in the level of knowledge of the SDGs across study years among the students
H1: There is a significant difference in the level of knowledge of the SDGs across study years among the students
P value = 0,19 = 19% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across study years

Figure 23: Knowledge of the Sustainable Development Goals and Black Carbon across study years among students

Among the student participants, there were also no statistically significant differences found in the level of knowledge of the SDGs (p = 0,19) or of BC (p = 0,9) across the study years.

Differences between income categories

The income categories used in the teacher survey differed from the ones of the student one. The teachers had one less income category to choose from, where the starting annual household income was 10 000 (10 000- 20 000; 20-001-40 000; 40 001-60 000; +60 000). Because there were no answers in the lowest income category, it was excluded from the statistical analysis. The students had an additional category with a chose of under 10 000. All incomes in the statistical tests were in euros.

Kruskal-Wallis Test

	Income	N	Mean Rank
KnowledgeSDGs	20 001-40 000	2	11,00
	40 001-60 000	8	21,19
	+60 000	16	16,09
	prefer not to answer	8	18,25
	Total	34	
KnowledgeBC	20 001-40 000	2	23,50
	40 001-60 000	8	17,69
	+60 000	16	18,25
	prefer not to answer	8	14,31
	Total	34	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	3,106	2,038
df	3	3
Asymp. Sig.	,376	,565

a. Kruskal Wallis Test

b. Grouping Variable: Income

H0: There is no significant difference in the level of knowledge of BC across income categories among the teachers
H1: There is a significant difference in the level of knowledge of BC across income categories among the teachers
P value = 0,565 = 57% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across income categories

H0: There is no significant difference in the level of knowledge of the SDGs across income categories among the teachers
H1: There is a significant difference in the level of knowledge of the SDGs across income categories among the teachers
P value = 0,376 = 38% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across income categories

Figure 24: Knowledge of the Sustainable Development Goals and Black Carbon across income categories among teachers

Among the teachers, there were no statistically significant differences found in the level of knowledge of the SDGs (p = 0,376) or of BC (p = 0,565) (Figure 24).

Kruskal-Wallis Test

	Income	N	Mean Rank
KnowledgeSDGs	under 10 000	95	143,24
	10 001-20 000	48	170,30
	20 001-40 000	50	166,73
	40 000-60 000	34	147,99
	+60 000	46	153,18
	prefer not to answer	33	144,67
	Total	306	
KnowledgeBC	under 10 000	93	158,73
	10 001-20 000	48	157,94
	20 001-40 000	50	159,78
	40 000-60 000	34	152,68
	+60 000	46	142,33
	prefer not to answer	33	130,02
	Total	304	

Test Statistics[a,b]

	KnowledgeSDGs	KnowledgeBC
Kruskal-Wallis H	5,104	4,358
df	5	5
Asymp. Sig.	,403	,499

a. Kruskal Wallis Test

b. Grouping Variable: Income

H0: There is no significant difference in the level of knowledge of BC across income categories among the students
H1: There is a significant difference in the level of knowledge of BC across income categories among the students
P value = 0,499 = 50% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of BC across income categories

H0: There is no significant difference in the level of knowledge of the SDGs across income categories among the students
H1: There is a significant difference in the level of knowledge of the SDGs across income categories among the students
P value = 0,403 = 40% >> 5%
=> There is not enough evidence to reject H0
=> There is no significant difference in the level of knowledge of the SDGs across income categories

Figure 25: Knowledge of the Sustainable Development Goals and Black Carbon across income categories among students

The same was concluded among the students, with no significant differences in the knowledge of the SDGs (p = 0,403) or of BC (p = 0,499) across the income categories (Figure 25).

4.3 The main information channels students and teachers learn from

The information channels for the SDGs and BC were investigated by a survey question where teachers and students could choose multiple answers. The percentages per channel were calculated op basis of the total number of student or teacher participants within that group.

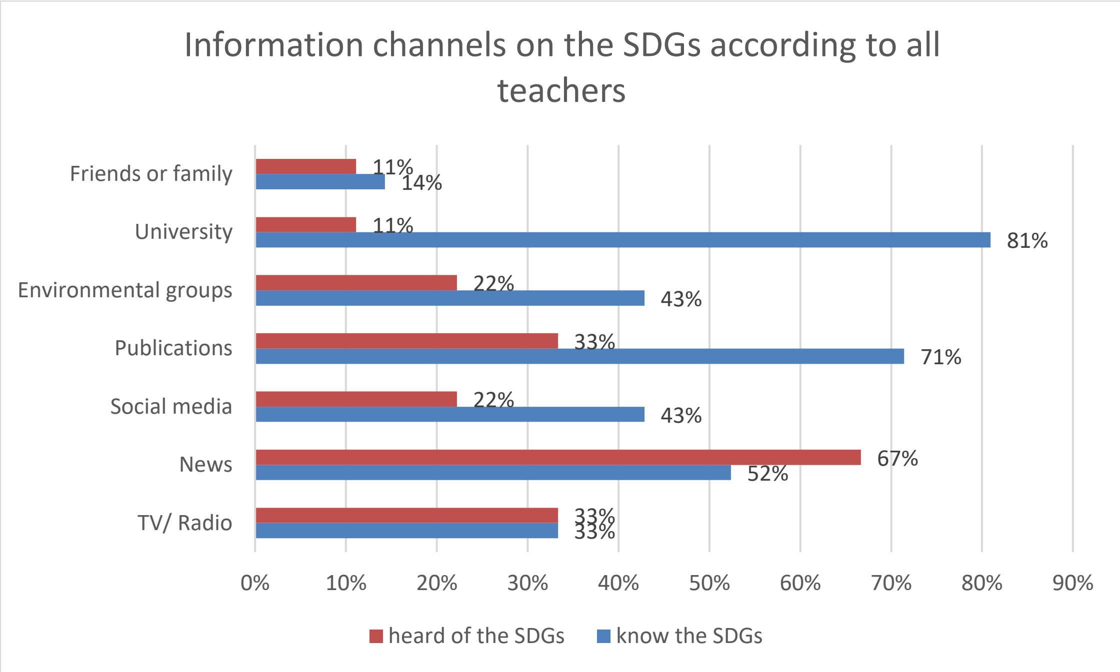


Figure 26: Information channels on the Sustainable Development Goals used by teachers

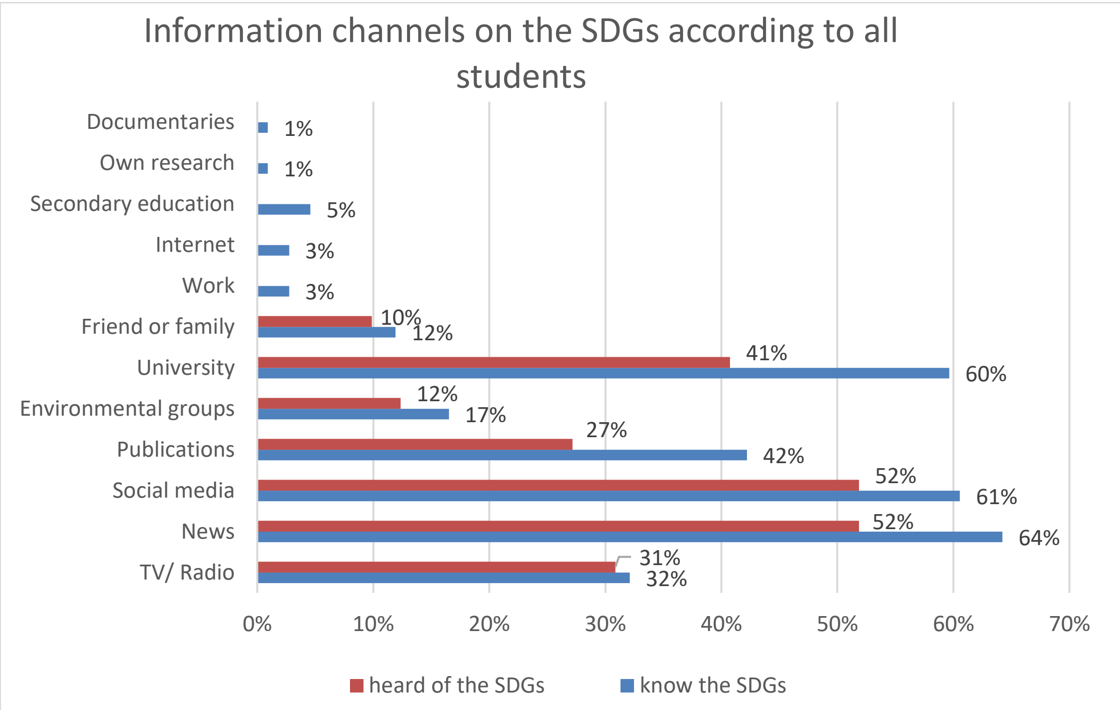


Figure 27: Information channels on the Sustainable Development Goals used by students

The teachers that knew the SDGs learned about them mostly through university (81%) or publications (71%). The news (52%) and environmental groups (43%) were the next most used channels. The ones that had only heard of the SDGs were mostly getting their information from the news (67%) and some from publications (33%), tv and radio (33%). Only few got their information from university (11%) (Figure 26). When it came to the students, they got their information predominantly from the news (64%) and social media (61%) but university was also high on the list

(60%). The same channels were mostly used by both students that knew the SDGs and that had heard of them (Figure 27).

Black Carbon

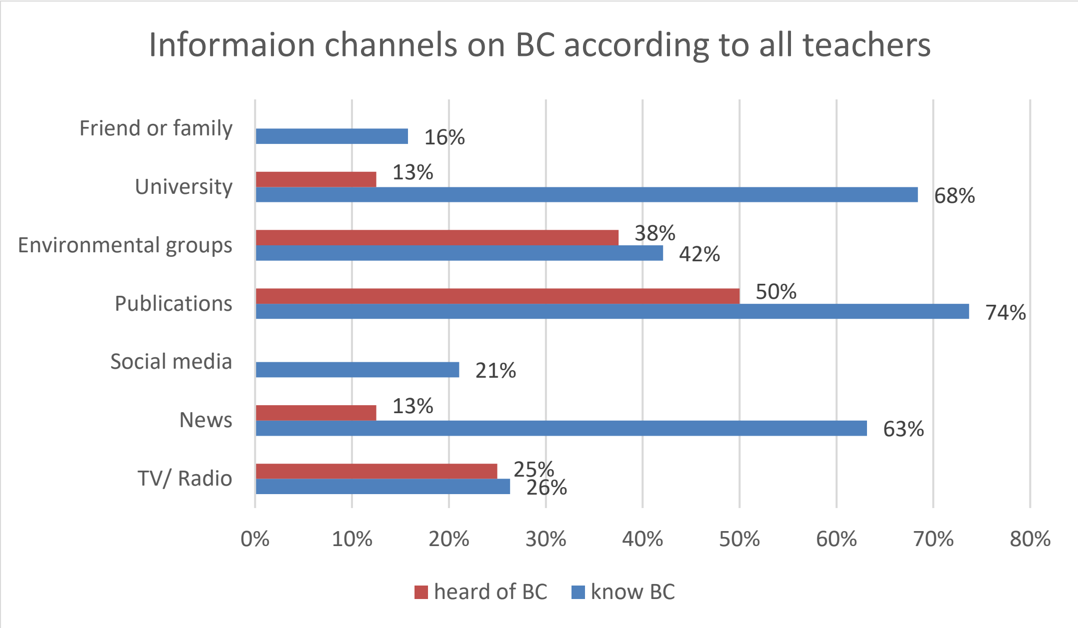


Figure 28: Information channels on Black Carbon used by teachers

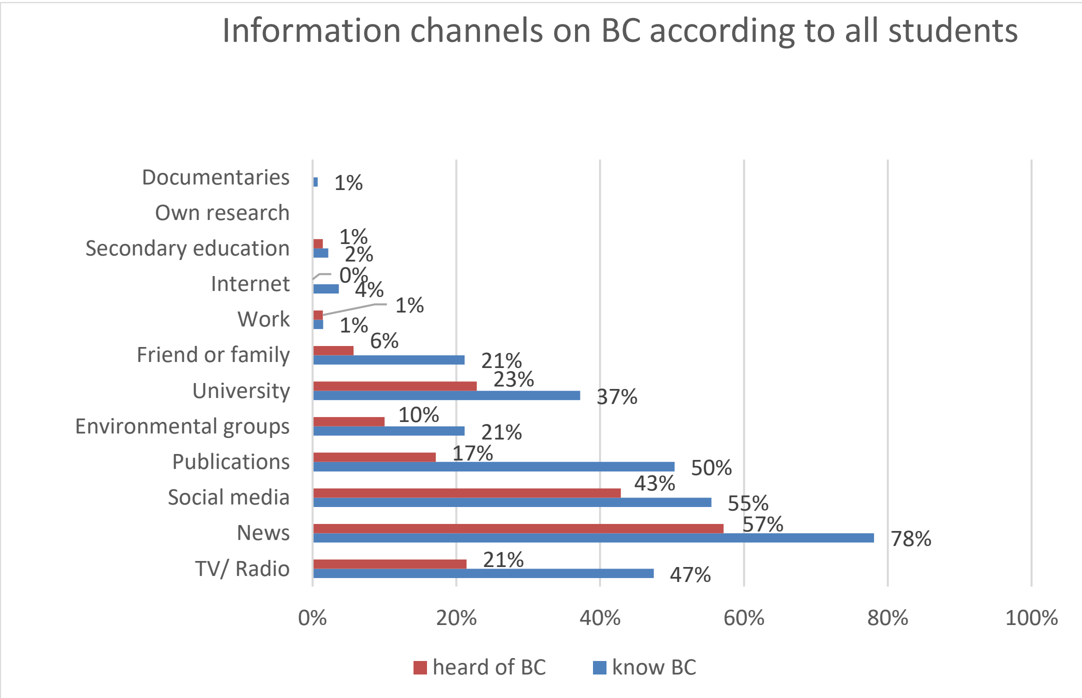


Figure 29: Information channels on Black Carbon used by students

Most teachers that answered they know BC, got their information from publications (74%), university (68%) and or from the news (63%). The ones that had only heard the topic mostly got their information from publications (50%) and environmental groups (38%) (Figure 28). Most students that knew BC got their information from the news (78%), social media (55%), publications (50%) and university (37%). If the students had heard of the topic, they received information mainly from the news (57%) and social media (43%). From that group, only 23% received information from university on the topic (Figure 29).

4.4 The current attitudes on sustainability of students and teachers

In order to investigate the possibility of future improvements, the current attitudes of students and teachers were evaluated. Both students and teachers were asked about how important they find the SDGs, as well as what sustainable actions they took.

From the student and teacher participants, 85% of teachers found the SDGs very important while 77% of students shared the same opinion.

Table 7: Most common actions on sustainability of teachers and students

Current actions on sustainability	Teachers	Students
Recycle	91%	75%
Save electricity	68%	60%
Use less plastic	65%	53%
Buy more locally grown food	62%	53%
Save water	44%	52%
Use the bike instead of the car	62	44%
Eat less meat	47%	42%

There were 7 main actions that both students and teachers took. Recycling, saving electricity, using less plastic and eating and buying locally grown food were at the top of the list (Table 7). Actions such as buying sustainable and biological products, consuming less and being vegan or vegetarian were also common. Nevertheless, it was found that 29% of all students do not take any action. Several reasons for the lack of action were mentioned. Russian students argued that there were not enough recycling facilities available and there was a lack of choice for sustainable and biological products. Finnish students added that the distances were too great to use the bike and the public transport was often not present or had a spread out timetable. This also affected their recycling behaviour since facilities were further away. Furthermore, there were concerns about the price of the local and bio food. The teachers mentioned that there was a lack of information on sustainable products.

4.5 The opinions and suggestions of teachers and students around governmental practises

The teachers and students were asked if the government has a clear vision on reducing emissions, according to them. Another question was how strict the governmental laws should be regarding pollution. In addition, it was possible to add opinions and suggestions. The participants were also asked about the timeframe of the governmental action plan, the responsible actors and what the end goal should be.

Table 8: Opinions of teachers and students on the government's vision on reducing emissions

Does the government have a clear vision reducing emissions?	Yes	No	Do not know
Teachers	50%	26%	24%
Students	26%	41%	33%

Most teachers thought that their government has sustainable practises (79%). Only half of the students however shared this opinion, while 20% didn't know if that is true. When it came to the vision of the government, the results were more spread out with only 50% of teachers that agreed that there is a clear vision and 41% of students that disagreed with the statement (Table 8).

When asked to share knowledge of this vision, teachers from Norway mentioned that the vision around reducing emissions was sometimes inefficient and there were not enough actions taken. Finland's teachers referred to the national carbon neutrality target, as well as reducing overall pollution from diesel exhausts and focusing on circular economy and waste reduction. From the Russian side was mentioned that communal waste processing and working towards joining the Green Deal is a great start for reducing pollution. Students mentioned similar points in their region, as well as more general ideas around increasing renewable energy and promoting electric cars.

Table 9: Opinions of teachers and students on how strict governmental laws should be around emissions

How strict should the laws become regarding emission reduction?	Much more strict	Somewhat more strict	Slightly more strict	Do not know
Teachers	32%	35%	6%	26%
Students	15%	30%	22%	32%

The majority of participants agreed that laws on reducing pollution should become stricter, with a confirmation of 82% from teachers and 70% from students. The opinions on how strict should these laws become were varied. The answer most frequently chosen was that the laws should become somewhat more strict (Table 9).

There were quite a few suggestions made on what the government should focus on when it comes to reducing emissions.

Teachers from Norway suggested a stronger financial support is needed for companies that focus on alternative technologies and green energy sources, as well as more accessible and reliable public transportation services. Finnish teachers added that there is more involvement needed with big polluting corporations, a stronger international network and more investments in development projects that promote sustainable practises.

Students from Russia shared that the government should better integrate environmental actions into its vision and laws. Taxes should be raised for polluting activities, the energy production facilities should be better controlled, and the research projects that are involved in clean energy and improving technologies should receive financial help. Norwegian students added that the focus on the supply chain should increase, the focus on extracting oil has to shift to developing the green energy sector and that public transport should be made more affordable. Most of the previously mentioned ideas were also part of the student suggestions from the Finnish side. There were however also many new ideas, such as creating an awards program for restaurants and organizations that successfully implement sustainable practises into their business, promoting the use of vegetarian food, monitoring better emissions from agriculture and mining activities, raising awareness of climate change through initiatives and making recycling mandatory.

The majority agreed that the government should take action now. 71% of teachers and 64% of students agreed with this statement, while around 20% of both groups thought that action should be taken in the next few years. Furthermore, two-thirds of all students and teachers shared the opinion that everyone is responsible for contributing to reducing emissions. Half of the teachers however believed that climate neutrality should be the ultimate goal, followed by zero waste and a 50-70%

reduction. 36% of students chose for a 50-70% reduction, while only 28% for climate neutrality and 22% for zero waste.

4.6 The opinions and suggestions of teachers and students around university education

In order to look for possible improvements, the current integration of the topics in the curriculums was evaluated. The participants were asked if their lessons integrate the topics, if they influence their way of thinking and what can be improved. Furthermore, both students and teachers were asked on how environmental friendly is their university and how they it can improve. Some questions in this category focused more on the SDGs than BC because of the specific nature of the topic.

Sustainable Development Goals

Out of all teachers, 53% didn't integrate the SDGs as a topic and the same was reflected on the students with 51% that had no integration of the topic in their curriculum.
When it came to communicating the topic of sustainability with students, most teachers either helped students become more mindful of the topic (44%) or motivated them to research further (32%). From the student's perspective, 31% see their lessons helped them become more mindful while 47% thought their education has no impact on their way of thinking. As a result of this, 67% of students and 88% of teachers agreed that the education system should better integrate the SDGs. Half of all participants thought that universities should include sustainability in all disciplines, while the other half thought the topic should at least be included in some.

While all teacher participants confirmed that each university had recycling bins, there was some confusion between 11% of Norwegian and 7% of Finnish students that stated the opposite. All Russian students also stated there are no recycle bins available at the MSTU.

Overall, 85% of teachers and 73% of students shared the opinion that their universities can be more environmental friendly. Teachers raised the importance of energy saving and efficiency, more recycle bins at the campus, more local food in the cafeteria and more vegetarian options needed. Russian professors suggested that ecological themed days can be a great way to capture students attention and raise awareness. To these suggestions, students added that digitalizing study material is important to reduce excess paper used. The universities should also find ways to reduce food waste, promote sustainable snacks, serve less meat options at the cafeteria, use more eco cleaning products and switch to using alternative energy sources if possible. In Finland and Norway students suggested that more campaigns should exist to raise knowledge in the topic, as well as mentioned the importance of having electric charging stations can help assist electrical transition. Students in all three regions stated that there is a need for more recycling bins on the campus.

Black Carbon

When participants were asked if the education systems should integrate more the topic of BC, 74% of teachers and 60% of students said yes.

Teachers from Norway prosed for the topic to be integrated in all environment related studies under which environmental chemistry, sustainability topics and ecotoxicology. In Finland, teachers stated that all students should be made aware of this topic at some point of their studies and that BC should definitely be integrated into engineering, tourism, business and urban planning degrees. Russian professors also raised the importance of the topic inclusion in international cooperation and cross-border environmental protection. The view of the students in the three regions only confirmed what the professors already stated.

5 Discussion

Results reliability

The answers from the distributed survey gave a broad overview of the knowledge of the SDGs and BC among the students, and a more limited one among the teachers. With the available data, there were limited statistically significant differences found in the level of knowledge of the SDGs or BC. Despite the fact that different channels and ways of communication were used, the response rate in Norway and Russia was low. This possibly indicated a lack of knowledge or interest on the topics. The limited number of responses and the fact that survey questions were transcribed in nominal variables, only allowed for parametric tests to be conducted. In that case, the reliability of the results across some variables could not always be guaranteed. This was especially true when the knowledge between countries or among the teachers was analyzed. Furthermore, most responses came from LUAS and therefore the conclusions reflect mostly the situation in Finland.

The differences between countries

Through the literature study, there were multiple differences found between Finland, Norway and Russia. This was on the state of emissions and the governmental and university practices around the SDGs and BC. Therefore, it was expected to find differences in the level of knowledge across the countries. There was a statistically significant difference found between Finland and Norway when a statistical test including all participants was conducted. In addition, the same difference was suspected among the teacher participants. Due to the low number of teacher responses however, a more conservative test was used as post hoc that resulted in no difference. The first significance between Finland and Norway has possibly to also be discarded due to a low number of responses. The uneven response rate across countries has to be taken into account when concluding differences in knowledge. Finland had a much higher response rate than the other two countries. Therefore, it is not certain if the difference is reliable or representative. Conclusions have to be carefully be drawn due to possible bias.

The differences between students and teachers

Before the results were analyzed, some assumptions were made about the level of knowledge of the SDGs and BC, based on the literature study. Even though previous studies had varied results on the knowledge of the SDGs, it was expected that a survey within university education will result in high knowledge of the topic. The Global Survey and the Youth Speak Global Report for example had similar conclusions, where just under half of the world's population knew the concept of the SDGs (AIESEC, 2016; Schlange et al., 2020). The Eurobarometer study however argued that these results related only to the people that had heard of the topic, whereas only about 10% of Europeans actually knew the SDGs (European Union, 2017). These statements were however an overview of the population and were not focused on universities. Also, there was no mention of BC. There were no studies on the knowledge of BC, making it hard to predict the outcome. Even though it was assumed that participants that knew the SDGs had a higher chance of knowing BC, it was uncertain if that was the case since the topic was more specific.

When the results were compared across the three universities, both students and teachers associated the same words with the SDGs. However, students that knew the SDGs scored only between 30% and 36%, where as teachers between 42% and 100%. The students scored lower than the scores suggested by the first two studies in the literature, whereas the teachers scored much higher. However, it has to be mentioned that the data of the teachers in Norway and Russia was possibly not reliable once again due to the limited response rate. Even though analysis among the teachers was not representative, the combined data from the teachers was used for other analysis. It was possible to reliably compare the knowledge between teachers and students. It was clear that teachers had a higher knowledge than students on the SDGs. This was also confirmed by most

teachers answering that they know between 7 and 12 SDGs, while the students mostly between 1 and 7. These assumptions were confirmed by a statistical analysis.
Conclusion on the knowledge of BC was harder to make since there was no statistical significance between the two groups. Even though it seemed like teachers knew BC better, there was not enough evidence to prove that statement. Also, both groups had similar answers on the additional questions. The word associations were similar, as well as the answers on the health effects and BC sources.

Topic integration

It was already stated in different studies that knowledge of the SDGs is fragmented and should better be integrated into different disciplines (Eagan et al., 2002). After researching about initiatives within the LUAS, it was expected that the integration and knowledge would be higher at this university. It was therefore surprising that only half of the students and teachers had the topic of the SDGs in their curriculum. Also, while most teachers in LUAS thought that they either helped students become more mindful of the topic or motivated them to research more on it, the students' perspective was different. One third of them had lessons that helped them become more mindful, while all the rest thought that their lessons didn't change their behavior at all. There was however a consensus on the fact that a better integration of the SDGs and BC is needed, though it was uncertain whether the topics should be included in some or in all university disciplines.

A better integration will help students understand how their disciplines are interconnected with the topics. This will help them to grasp the complexity of the problems related to the achievement of the SDGs, as well as pollution and climate change in general (Annan-Diab and Molinari, 2017; Defries et al., 2012). The importance of an interdisciplinary approach to the SDGs within the education system has already been prioritized by UNESCO (UNESCO, 2005) (UNESCO, 2014). Its implementation can however be complicated, where multiple strategies have to be considered (Summers et al., 2005; Zamora-Polo and Sánchez-Martín, 2019). The outbreak of Covid last year made universities have to adjust their educational practises and possibly made the distribution of knowledge more complex. Nevertheless, quality education is one of the SDGs that requires most urgent action, along with climate action and responsible consumption and production (Schlange, Frank and Cort, 2020). By integrating sustainability and BC into the education, not only the quality of the learning is improved, but achievement of all other SDGs is supported as well (Zamora-Polo *et al.*, 2019).

Information channels

Initially, it was suspected that university, news and social media will be the most common channels on the SDGs and BC, both among students and teachers. The survey results confirmed that statement but there were some variations between the groups. When the information channels on the topics were analyzed, it was clear that teachers that knew the SDGs and BC mostly got information from the university or publications. The ones that had only heard of the SDGs used the news, tv/radio or publications, while the ones that had heard of BC used publications and environmental groups. This could suggest that unless teachers worked around the topics, they only heard about them from channels outside the university. On both topics, students mostly got information from the news and social media, where the university came in third place. The reason for the news and social media to be so often used could be the lack of integration of the SDGs and BC into the curriculums. Information from the news and social media is not always reliable and can influence the opinions on the topics as well. It is therefore important for universities to understand the obligation they have, being among the most used information channels. It could be that topics might be well integrated into some disciplines, but not in others. Perhaps the SDGs come only in certain courses throughout the study program and some students did not yet learn about them. It is also possible that even if the university includes the goals into many activities, due to a lack of initiatives the students are unaware of their actions. This is most likely the case with LUAS. In comparison to the other two universities of Uit and MSTU, LUAS promoted their sustainable behavior much better. Perhaps the universities have to find a better approach to communicate with students and staff members, especially using social media or other digital ways. The digital world is the new way to communicate. It provides the opportunity to spark the interest on the SDGs and BC, therefore contributing to a higher level of knowledge.

Personal actions

Even though research showed that more than half of the world's population considers sustainability when purchasing food (Schlange, Frank and Cort, 2020), because of the challenging times during the pandemic it was not clear what the results will be. It was a pleasant surprise to see that most teachers and students found the SDGs very important and were already were taking various sustainable actions, such as recycling, saving water and electricity, using less plastic and consuming less meat and more local food. That confirmed that short-term actions are most often favored (Schlange, Frank and Cort, 2020). However, almost one third of students that took no action. This is possibly due to the multiple reasons mentioned such as a lack of recycling facilities close by, insufficient choice of biological products, big distances or just financial reasons.

University actions

When it came to the universities' actions, participants thought that more effort is needed to be environmentally friendly. The suggestions on the way to promote sustainability were meaningful and interesting, showing that there was a deeper understanding on the topics. Often suggestions such as more recycling bins, a wider variety of vegan, vegetarian, local or biological food options and more digital material, came up. In MSTU for example, students mentioned the lack of recycle bins at the university. This was surprising since the actions mentioned were already expected to be taken by all three organizations. The suggestions and comments of the students can therefore mean that either the universities are not putting enough effort to be sustainable, or that the students have the wrong impression. Because a lot of lessons are taking place online, it is possible that many students from the first and second year have not yet been on campus. LUAS already mentioned that vegetarian dishes are one of the most chosen dishes at the school cafeteria. There was in general more information acquired on the practices of LUAS, possibly due to the higher response rate and a better communication flow. Even like this, the lack of recycle bins in Russia can be seen as an indicator the lack of integration of common sustainable actions. This should further be investigated.
Regarding BC, there were many suggestions on integrating it more in the already expected sectors such as engineering, tourism, business and urban planning degrees. These are degrees that possibly also include the SDGs. This indicates that there is perhaps a limited understanding of the consequences related to the topic, where participants miss to see the importance of it across the disciplines. There were however suggestion on the topic integration across international projects. In this sense, there is an awareness that it is a multidisciplinary topic.

Governmental actions

When it came to the governmental practices, it was already considered possible that students might not have a high knowledge of them yet. This statement turned out to be true with one third of them that did not know about the governments vision. Most students thought there is no clear vision, while the teachers shared the opposite opinion. This of course meant that most teachers believed that the government has sustainable practices, while the same was much less common among the students. This also resulted in more vague explanations when they were asked to clarify the vision. Still, most participants agreed that action has to be taken now and that the laws should be stricter with a focus on alternative energy by supporting innovation and research. Almost all participants agreed that everyone is responsible and has to take action. There was no consensus however on what the end goal has to be. This confusion was unexpected since Finland is clearly promoting becoming climate neutral by 2035.

6 Conclusion

The region of Lapland was found to be strongly involved in sustainability. In comparison to Troms and Murmansk regions, there was more information available on the topic and it was better promoted at the university. Lapland University of Applied Sciences has recently created a team that focuses on integrating the SDGs better in study programs, as well as university activities.

The survey itself resulted in limited statistical differences in the level of knowledge of the SDGs and BC. There was a possible significance in the knowledge of the SDGs between Finland and Norway but no conclusions were made, due to possible bias as a result of the uneven response rate across the countries. Very few answers came from Norway and Russia, making part of the analyses unreliable. Nevertheless, it was concluded that teachers have a higher knowledge of the SDGs than students. The results reflected best the situation in Finland.

When the knowledge of the SDGs and BC was assessed, it was found to be fragmented. Only half of the teachers and students had the topic of the SDGs integrated in their curriculums and most students did not feel impacted by their lessons. Even though most participants found the SDGs very important and took sustainable action, almost a third of the students took no action. There was however a consensus that the universities should put more effort to be environmental friendly. Multiple actions were suggested such as more sustainable food options, more recycle bins and more digital material. It was also mentioned that BC should to be included in more courses, as well as international projects. The knowledge of the governmental strategy was low among students. While most of them thought the government had unsustainable practises, a third of them did not know the vision itself. When the information channels on the SDGs and BC were evaluated, the universities were found to be one of the most important ones, both among teachers and students. Teachers relied slightly more on the university and publications as information sources, while students focused more on the news and social media.

BC mitigation directly contributes to combating climate change and supports the achievement of the SDGs. Since half of the world’s population is made up of young adults, helping raise their awareness and improve their knowledge of the topics of the SDGs and BC is crucial. The universities have therefore an obligation to act as role models, as well as provide teachers and students with reliable information on the topics. An interdisciplinary approach and innovative communication techniques are needed to help students better comprehend the complexity of the situation and motivate them to take action steps towards a brighter and more sustainable future. This is definitely important in the current situation that has left society no other choice but to virtually connect.

‘’We change the world one small action at a time’’

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8 Appendices

8.1 Questionnaire on Sustainable Development Goals and Black Carbon targeting students in Lapland, Troms and Murmansk

The research is part of the project: Capacity Building for Black Carbon mitigation efforts: a roadmap for cross-border activities between Finland, Norway and Russia. This questionnaire aims to investigate if there is a gap of knowledge among the educators and the youth. By taking part you have a chance to win a chocolate gift box.

All questions marked with * are obligatory

1. Do you agree for your answers to be used for research that aims to reduce Black Carbon emissions in the Arctic? *
   A. I agree
   B. I don't want to take part of this questionnaire

Part 1: General questions

2. What is your gender? *
   A. Male
   B. Female
   C. I prefer not to answer

3. How old are you? *
   A. 18-22
   B. 23-30
   C. +30

4. In which sector are you professionally involved through studies? *
   A. Environment
   B. Tourism
   C. Engineering
   D. Other …

5. What is the name of the degree program and university you are involved in? *
   …

6. In which year of university study are you? *
   A. 1st year
   B. 2nd year
   C. 3rd year
   D. 4th year
   E. 5th year

7. What is your average household income? *

Finland survey:

   A. Under 10 000 euro

B. 10 001 - 20 000 euro
C. 20 001 - 40 000 euro
D. 40 001 - 60 000 euro
E. +60 000 euro
F. I prefer not to answer

Norway survey:

A. Under 100 000 krone
B. 100 001 - 200 000 krone
C. 200 001 - 400 000 krone
D. 400 001 - 600 000 krone
E. +600 000 krone
F. I prefer not to answer

Russia survey:

A. Under 875 000 ruble
B. 875 001 - 1 750 000 ruble
C. 1 750 001 - 3 500 000 ruble
D. 3 500 001 - 5 250 000 ruble
E. +5 250 000 ruble
F. I prefer not to answer

Part 2: Assess knowledge of Sustainable Development Goals (SDGs)

8. Do you know what SDGs are? *
   A. Yes
   B. I have heard the name but have no idea what it means
   C. No idea

If answer in QN8 is A or B

8.1 Where did you hear about the SDGs? (Choose multiple answers) *
   A. TV Radio
   B. News
   C. Social media
   D. Publications
   E. Environmental groups
   F. University
   G. Friends or family
   H. Other…

If answer in QN8 was A, after 8.1 => 8.2

8.2 What key words do you associate with the SDGs? *
…

8.3 How many SDGs do you know? *
……

8.4 How important are the SDGs in your opinion? *

A. Very important
B. Fairly important
C. Not important

Part 3: Assess knowledge of Black Carbon (BC)

9. Have you heard of Black Carbon? *
   A. Yes
   B. I have heard the name but have no idea what it means
   C. No idea

If answer in QN9 is A or B

9.1 Where did you hear about Black Carbon? (Choose multiple answers) *
   A. TV Radio
   B. News
   C. Social media
   D. Publications
   E. Environmental groups
   F. University
   G. Friends or family
   H. Other …

9.2 What problems do you associate with Black Carbon emissions? *
   …

9.3 What negative effects do you think Black Carbon can cause on human health? (Multiple answers possible) *
   A. Affects cardiovascular system: blood, heart, blood vessels
   B. Causes headaches
   C. Creates respiratory problems
   D. Creates eye problems
   E. I don't know

9.4 What do you think is the biggest source of Black Carbon in your region?
   A. Mining activities
   B. Maritime shipping
   C. Transport
   D. Wood burning for heating
   E. I don't know

Part 4: Assess the integration of Sustainable Development Goals (SDGs) and Black Carbon (BC) in the higher education system

10. Do your studies integrate SDGs as a topic? *

   A. Yes
   B. No
   C. I don't know what SDGs are

11. If yes, in which topic or subject?
    …

12. Do you think that the education system should teach us more about the topic of SDGs? *
    A. Yes
    B. No
    C. I don't know what SDGs are

13. Do you think that the education system should teach us more about the topic of Black Carbon? *
    A. Yes
    B. No
    C. I don't know what Black Carbon is

14. In which courses do you think the topic of sustainability and Black Carbon emissions should be integrated?
    …

15. Finish the sentence: *
    My studies have:
    A. Motivated me to research more on the topic of sustainability and environmental degradation
    B. Helped me become more mindful about sustainability
    C. Helped me to start living in a more sustainable way
    D. Have not changed my attitude on sustainability

16. Choose the answer that in your opinion is best suitable to finish the statement: *
    Sustainability should be integrated into the curriculum of …
    A. Universities at least in some disciplines
    B. Universities in all study disciplines

17. Does your university recycle trash? *
    A. Yes
    B. No

18. Do you think that your university should put more effort to be environmental friendly? *
    A. Yes
    B. No

19. What suggestions do you have for your university to become more environmental friendly?
    …

Part 5: Attitudes and opinions

20. Which actions are you personally taking to be more environmental friendly? (Multiple answers possible) *
    A. I use more the bike and public transport instead of my car
    B. I eat meat coming from sustainable farms
    C. I eat less meat in general and try to eat more vegetables or other protein substitutes
    D. I buy biological products
    E. I eat locally grown food

F. I buy clothes that are sustainably produced
G. I recycle all trash possible
H. I choose for recycle friendly packaging and bags instead of plastic
I. I save water
J. I save electricity
K. I don't do anything to be environmental friendly
L. Other …

21. If you are not taking action to be more environmental friendly, what are the reasons?
    …

22. Does the government promote sustainable practices in your opinion?
    A. Yes
    B. No
    C. I don't know

23. Does the government have a clear vision for the future on reducing air pollution? *
    A. Yes
    B. No
    C. I don't know

24. If yes, do you know what is this vision?
    …

25. Should the government's laws become stricter in order to reduce air pollution from pollutants such as Black Carbon?
    A. Yes
    B. No

26. If yes, how strict should laws become in your opinion? *
    A. Much more strict
    B. Somewhat more strict
    C. Slightly more strict
    D. I don't know

27. Which actions should the government undertake in your opinion to reduce emissions?
    …

28. When should the government take action? *
    A. Now
    B. In the next few years
    C. In the next 10 years
    D. In the next 50 years

29. Who do you think is responsible for reducing air polluting emissions? (Multiple answers possible) *
    A. Government
    B. Non-governmental organizations (NGOs)

C. Private owners
D. Individuals
E. Research organizations
F. Everyone
G. Other …

30. What should the ultimate goal be in your opinion? *
    A. Completely climate neutral
    B. Zero waste production
    C. Reduce 50-70% of emissions
    D. Reduce 20-50% of emissions

8.2 Questionnaire on Sustainable Development Goals and Black Carbon targeting teachers in Lapland, Troms and Murmansk

The research is part of the project: Capacity Building for Black Carbon mitigation efforts: a roadmap for cross-border activities between Finland, Norway and Russia. This questionnaire aims to investigate if there is a gap of knowledge among the educators and the youth. By taking part you have a chance to will a raw chocolate gift box.

All questions marked with * are obligatory

1. Do you agree for your answers to be used for research that aims to reduce Black Carbon emissions in the Arctic? *
   A. I agree
   B. I don't want to take part of this questionnaire

Part 1: General questions

2. What is your gender? *
   A. Male
   B. Female
   C. I prefer not to answer

3. How old are you? *
   A. 21-30
   B. 31-40
   C. 41-50
   D. +50
   E. +65

4. In which sector are you professionally involved through teachings? *
   A. Environment
   B. Tourism
   C. Engineering
   D. Other …

5. What is the name of the degree program and university you are involved in? *
   …

6. How many year have you worked at the university? *
   …

7. What is your average household income? *

Finland survey:

A. Under 10 000 euro
B. 10 001 - 20 000 euro
C. 20 001 - 40 000 euro
D. 40 001 - 60 000 euro
E. +60 000 euro

F. I prefer not to answer

Norway survey:

A. Under 100 000 krone
B. 100 001 - 200 000 krone
C. 200 001 - 400 000 krone
D. 400 001 - 600 000 krone
E. +600 000 krone
F. I prefer not to answer

Russia survey:

A. Under 875 000 ruble
B. 875 001 - 1 750 000 ruble
C. 1 750 001 - 3 500 000 ruble
D. 3 500 001 - 5 250 000 ruble
E. +5 250 000 ruble
F. I prefer not to answer

Part 2: Assess knowledge of Sustainable Development Goals (SDGs)

8. Do you know what SDGs are? *
   A. Yes
   B. I have heard the name but have no idea what it means
   C. No idea

If answer in QN8 is A or B

8.1 Where did you hear about the SDGs? (Choose multiple answers) *
   A. TV Radio
   B. News
   C. Social media
   D. Publications
   E. Environmental groups
   F. University
   G. Friends or family
   H. Other…

If answer in QN8 was A, after 8.1 => 8.2

8.2 What key words do you associate with the SDGs? *
   …

8.3 How many SDGs do you know? *
   ……

8.4 How important are the SDGs in your opinion? *
   A. Very important

B. Fairly important
C. Not important

Part 3: Assess knowledge of Black Carbon (BC)

9. Have you heard of Black Carbon? *
   A. Yes
   B. I have heard the name but have no idea what it means
   C. No idea

If answer in QN9 is A or B

9.1 Where did you hear about Black Carbon? (Choose multiple answers) *
   A. TV Radio
   B. News
   C. Social media
   D. Publications
   E. Environmental groups
   F. University
   G. Friends or family
   H. Other …

9.2 What problems do you associate with Black Carbon emissions? *
   …

9.3 What negative effects do you think Black Carbon can cause on human health? (Multiple answers possible) *
   A. Affects cardiovascular system: blood, heart, blood vessels
   B. Causes headaches
   C. Creates respiratory problems
   D. Creates eye problems
   E. I don't know

9.4 What do you think is the biggest source of Black Carbon in your region? *
   A. Mining activities
   B. Maritime shipping
   C. Transport
   D. Wood burning for heating
   E. I don't know

Part 3: Assess the integration of Sustainable Development Goals (SDGs) and Black Carbon (BC) in the higher education system

10. Do your lessons integrate SDGs as a topic? *

    A. Yes
    B. No
    C. I don't know what SDGs are

11. If yes, in which topic or subject?

…

12. Do you think that the education system should teach us more about the topic of SDGs? *
    A. Yes
    B. No
    C. I don't know what SDG are

13. Do you think that the education system should teach us more about the topic of Black Carbon? *
    A. Yes
    B. No
    C. I don't know what Black Carbon is

14. In which courses do you think the topic of sustainability and Black Carbon emissions should be integrated?
    …

15. Finish the sentence: *
    My lessons aim to:
    A. Motivate students to research more on the topic of sustainability and environmental degradation
    B. Help students become more mindful about sustainability
    C. Help students to start living in a more sustainable way
    D. Explain other topics than sustainability and for this reason don't change the attitude of students on sustainability

16. Choose the answer that in your opinion is best suitable to finish the statement:
    Sustainability should be integrated into the curriculum of … *
    A. Universities at least in some disciplines
    B. Universities in all study disciplines

17. Are there recycle bins at your university? *
    A. Yes
    B. No

18. Do you think that your university should put more effort to be environmental friendly? *
    A. Yes
    B. No

19. What suggestions do you have for your university to become more environmental friendly?
    …

Part 4: Attitudes and opinions

20. Which actions are you personally taking to be more environmental friendly? (Multiple answers possible) *
    A. I use more the bike and public transport instead of my car
    B. I eat meat coming from sustainable farms
    C. I eat less meat in general and try to eat more vegetables or protein substitutes
    D. I buy biological products

E. I eat locally grown food
F. I buy clothes that are sustainably produced
G. I recycle all trash possible
H. I choose for recycle friendly packaging and bags instead of plastic
I. I save water
J. I save electricity
K. I don't do anything to be environmental friendly

21. If you are not taking action to be more environmental friendly, what are the reasons?
…

22. Does the government promote sustainable practices in your opinion? *
A. Yes
B. No
C. I don't know

23. Does the government have a clear vision for the future on reducing air pollution? *
A. Yes
B. No
C. I don't know

24. If yes, do you know what is this vision?
…

25. Should the government's laws become stricter in order to reduce air pollution from pollutants such as Black Carbon? *
A. Yes
B. No

26. If yes, how strict should laws become in your opinion? *
A. Much more strict
B. Somewhat more strict
C. Slightly more strict
D. I don't know

27. Which actions should the government undertake in your opinion to reduce emissions?
…

28. When should these actions be taken? *
A. Now
B. In the next few years
C. In the next 10 years
D. In the next 50 years

29. Who do you think is responsible for reducing air polluting emissions? (Multiple answers possible) *
A. Government
B. Non-governmental organizations (NGOs)

C. Private owners
D. Individuals
E. Research organizations
F. Everyone
G. Other …

30. What should the ultimate goal be in your opinion? *
    A. Completely climate neutral
    B. Zero waste production
    C. Reduce 50-70% of emissions
    D. Reduce 20-50% of emissions