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Sustainability assessment and education for sustainability in the Russian Federation on the example of Tambov region

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Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
BOD	Biological oxygen demand
CFR	Central federal region
CI	Composite indicator
CKYL	Condorcet-Kemeny-Young-Levenglick
COIN	Competence Centre on Composite Indicators and Scoreboards
COP	Conference of the Parties
CSD	Commission of sustainable development
DEA	Data envelopment analysis
DSR	Driving force, state, and response
EMISS	Edinaya mezhvedomstvennaya informacionno-statisticheskaya sistema Unified interdepartmental information and statistical system
EU	European Union
EWI	Ecosystem Well- Being Index
FA	Factor analysis
Fedstat	Federal service of state statistics
GDP	Gross Domestic product
GHG	Greenhouse gas
GOST	State Russian standard
ha	Hectare
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
HWI	Human Well-being Index
IA	Impact assessment
INDC	Intended Nationally Determined Contributions
ISA	Integrated sustainability assessment
ISEW	Index of Sustainable Economic Welfare
Kg	Kilogram
KMO	Kaiser-Meyer-Olkin
Lisrel	Linear structural relations
LLC	Limited Liability Company
m3	cubic metre
MATISSE	Methods and tools for integrated sustainability assessment
MFA	Material flow analysis
Mg	Milligram
Mil.	Million
MROT	Minimal pay level
MSA	measure of sampling adequacy
NNP	Net National Product
OECD	Organization for Economic Cooperation and Development
PCA	Principal component analysis
PM	Particulate matter
RF	Russian Federation
Rosstat	Federal service of state statistics
Rub.	Roubles
SAMT	Sustainability Assessment Methods and Tools
SD	Sustainable development
SDG	Sustainable development goals
SIA	Sustainability impact assessment
SPM	Suspended Particulate matter

SWOT	Strengths, Weaknesses, Opportunities and Threats
TR	Tambov region
UCM	unobserved components model
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission of sustainable development
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
Vocs	volatile organic compounds
WHO	World Health Organization

Introduction

We don't get the earth as heritage from our ancestors, we just borrow it from our children.
American Indian proverb

1.1 Research background

The end of 20th century was marked with rising awareness of the human influence on the environment. The question how to meet human needs and to preserve the life-support systems of planet Earth simultaneously became especially important (Annan-Diab and Carolina, 2017; Annan, 2000; National Research Council Board on Sustainable Development, 1999; Watson et al., 1998). Available resources are limited and at the same time the needs of population are growing, society is becoming more concerned of the question how their decisions are influencing the future generations (Dahl, 2012; Foley et al., 2011; Pittelkow et al., 2014).

Since the publication of the UN report "Our common future" (WCED, 1987) by the World Commission on Environment and Development in 1987 and the accomplishment of the United Nations Conference on Environment and Development (UNCED) in 1992, the concept of ''sustainability'' has been adopted as key political principle by most governments worldwide (Rametsteiner et al., 2011). Word "sustainability" became very popular in both scientific and every-day life. It is used everywhere: in political and scientific discourses, in marketing strategies and in simple everyday talks. It is used as label, brand or icon to make acceptable to different interest groups and under various conditions (Raman, 2006).

The expression "Sustainable development" could be applied to almost every sphere of business and life; it could be social, economic, or ecologic. Many authors are discussing the philosophical nature of the concept, but to use the concept in the practice this philosophy should be transformed into a system of criteria (Kondyli, 2010; Ness et al., 2007; Pintér et al., 2012; Volkery et al., 2006).

Managers, politicians, scientists, consumers, city governments and many other decision-makers are asked to deal with the issues of sustainability, as the link between human activities and the future of earth´s natural systems become common knowledge, but suitable instruments are not always offered to assess and to monitor sustainability (van den Bergh et al., 1994). The decision-makers are not always aware of the fact that the sustainability is a complex systems issue with mutually interacting and often conflicting tenets (Raman, 2006). The complexity of the sustainability is not the only limiting factor, another problem is the fact that sustainability is an open-ended, dynamic, and continuously evolving process facing new challenges and threats all the time (Raman, 2006).

The term sustainability is defined, but the values of criteria and indicators are changing on a constant basis and new problems and challenges are arising (Pintér et al., 2012). The sustainability thinking is an never-ending process of negotiating the boundaries around what is both possible and preferable (Floyd and Zubevich, 2010).

The question of sustainability becomes important when it comes to feeding the growing population, by 2050 global population is projected to be almost 10 billion compared to 7,8 billion in 2020 and food production needs to increase by 70% to feed the global population (Odegard and Voet, 2014; Pardey et al., 2014; United Nations Publication, 2019). Agricultural production will have to double to keep pace with population growth and it will definitely change the life of rural areas which rely on agriculture (Pardey et al., 2014). During these changes it is important to monitor the sustainability of development to prevent irreversible changes that can damage the environment and the assessment of progress towards sustainable development is a subject of extreme importance (Espey, 2021; Estoque, 2020; Janker and Mann, 2020; Nilashi et al., 2019).

Many scientist are stressing the fact that identifying, assessing, monitoring and evaluating the sustainability of a system are very important to achieve the goal of sustainable development (Hellstroem et al., 2000; Lundin et al., 1999; Sachs et al., 2019). That is why there is a clear need for a practical tool which could help scientists as well as other decision-makers to assess

sustainability. The science around sustainability phenomenon is vast and the research of assessment methods is also not an exception (Pope et al., 2017a).

Sustainability assessment in practice includes on one hand the evaluation of the development potential of different policies and projects, on other hand – identification of the trends that are, or are not, sustainable, trends that pose severe or irreversible threats to our future quality of life (Becker, 2004; Emmanuel et al., 2007; Olsson et al., 2004). As a result progress towards sustainability could be identified and it would become clearer which behaviour is desirable in order to achieve sustainability (Barrow, 2018; Becker, 2004).

The debate around sustainability concept is still on-going, assessment methods, developing strategies, concretizing objectives are discussed (de Haan, 2006), but despite all the differences about formulation the essence of sustainability one thing stand out – to achieve sustainability a substantial far-reaching modification in the human way of life is needed (Kopfmüller et al., 2001). That is why in all the sustainability regulations adopted by the world community a special attention is paid to education (Guskova et al., 2016). Education was included in Agenda 21 and in 2005 the strategy of education for the sustainable development was adopted, in this strategy it was emphasized that education in addition to being the fundamental human right is a significant prerequisite for the sustainable development and the tool for effective governance, reasonable decision-making, and promotion of democracy (UNECE, 2005).

In last thirty years Russia has experienced economic and social change, which had a substantial impact on the regional and sectoral patterns of the development of its economy, infrastructure, the quality of environment and the well-being of its people (Nagimov et al., 2018; Shmelev, 2011). The sustainable development of Russian regions is affected by the significant decline in industrial production, environmental degradation, growing social inequality, unstable political situation and other factors (Gapsalamov et al., 2017).

In such conditions achievement of the sustainable development is becoming more and more challenging. Russia has participated in the 1992 Earth Summit (Oldfield and Shaw, 2002) and after this Summit a concept of transition to sustainable development was signed by the president of Russian Federation (Ukaz, 1996). After that there were regular introductions of different concepts and strategies for sustainable development and there are clearly some efforts to achieve sustainability in Russia, but still scientists are admitting that it is often that sustainability is present only on paper and it is often that the word “sustainable” is in the name of a strategy, but the strategy itself has nothing to do with sustainable development (Hmeleva, 2014; Newell and Henry, 2017; Pavlova, 2012), and in Russian official documents the term sustainability is quite often used in a context of sustainable (stable) economic growth (Bobylev and Solovyeva, 2017).

There are some examples of research devoted to sustainable development assessment in Russia. For example there are some attempts to find suitable indicators to assess sustainable development, but it usually highly subjective or it is based only local experts assessment (Bobylev, 2007). There are examples of the assessment by several regional governments with the methodology of adjusted savings (Bedrickij, 2012). There is also an example of research in which the dynamic sustainability is assessed on macro level with the help of multi-criteria methods (Shmelev, 2011), but a comprehensible tool to evaluate and to monitor the trends of development is missing.

Russia is also making some steps in statistical data collection, in 2017 the sustainable goal indicators were added to the federal plan of statistics collection and in 2020 the first Voluntary National Survey on Sustainability development goals was published (Analytical center of government of Russian Federation, 2020).

Coordination of sustainability efforts in Russia is formally conducted by the interagency taskforce for the Executive Office of the President of the Russian Federation. The taskforce has inspected the status of statistical data necessity for monitoring implementation of the SDGs in Russia and established a new expert group on info-statistical support for the monitoring, nevertheless until 2020 Russia has not laid out a national approach or a national strategy of sustainable development (Sakharov and Kolmar, 2019a).

Russia has joined the Bologna process and the higher education in Russia has met new challenges to ensure comparability in the standards and quality of higher education (Telegina and Schwengel, 2012). The topic of integration of sustainability into education is also present in the Russian scientific debates, but the researchers are admitting that it is often that the sustainability is present only on higher levels of education, and it is often substituted with ecological education or neglected at all (Bedrickij, 2012; Ilin et al., 2017; Kirillov et al., 2012; Lebedev and Neupokojeva, 2001; Pavlova, 2013).

The concept of sustainability is a complex structure consisting of various aspects, and to assess sustainability, suitable tools alone are not enough, the crucial thing is the presence of people who will use these tools and will have the right background and competences. As noted above, the achievement of sustainable development is possible only under conditions of a change in the usual way of life, and it is possible to achieve these changes only with an increase in the level of sustainability awareness.

Therefore, the focus of research within my dissertation was the analysis and search for suitable methods for assessing sustainability on example of one of the regions of the Russian Federation and the analysis of the state of education for sustainable development in Russian agricultural universities.

1.2 Research questions and objectives

The question "how to reach sustainability?" is remaining answered to this day, but there are on-going attempts to embrace and evaluate this phenomenon (European Commision, 2019; Eurostat, 2019; Pires et al., 2021). The most recent attempt to create a measurement system was in 2015 when at the United Nations General Assembly, countries around the world signed up to the 2030 Agenda for Sustainable Development (United Nations 2030 Agenda) and its 17 Sustainable Development Goals (SDGs), agreeing on a concrete actions which should be taken to contribute to sustainability (Eurostat, 2019; General Assembly of United Nation, 2019; United Nations Statistical Commission (UNSC), 2017). The next important step after setting of global aims is to assess and monitor the progress, there are several methodologies available and the aim of the first part of this study is to develop a practical applicable methodology for evaluation of region´s sustainability on the example of one of the regions of Russian Federation.

During this research, a solid conceptual procedure is created and not a one-fit-all solution. The results of the study should enable to demonstrate the advantages and disadvantages of the various methods used to construct composite sustainability indicators, demonstrating the usefulness of analysing several of these indicators in conjunction, to obtain more robust results. Such information could help to improve current policies with the aim to develop the region sustainably. This approach is quite innovative, as composite indicators are not widely used for the sustainability assessment in Russia (Ferova et al., 2019; Kalmykova, 2013).

The first part of the research devoted to sustainability assessment can be divided by two aspects, the first of these being methodological or theoretical, and the second, practical. In the first place, literature research is performed to get an overview of existing methodologies and make a choice for a suitable tool for an evaluation of regional sustainability. Then chosen methodology is applied to one of the regions in Russia. This empirical application enables to analyse the actual prospect of using sustainability as a decision-support tool for improving the "governance" of the region´s development.

A procedure for sustainability assessment in Russian Federation has not been widely reported. The aim of this thesis was to gain an understanding of the existing methodologies of sustainability assessment and to test suitability and applicability of different methodological approaches to sustainability assessment for Russian condition. The results of trend analysis with the help of composite indicators created with different methods were compared with the results of regional assessment, to check if these two methods could be used for sustainability assessment.

To fulfil this aim, following research questions were posed:

1. Which methodologies for sustainability assessment are usually used in scientific literature?
2. How is sustainability assessed in Russia?
3. Which methodologies could be applied in Russian conditions, considering available statistical data?
4. How are the different weighting and normalisation techniques influencing the results of the assessment?
5. What could become limiting factors for the application of the developed procedure?
6. Which areas for sustainability assessment needs further research?

This research is important for assessment of sustainability, especially with the focus on Russian Federation. It is interesting to investigate how the sustainability concept is integrated into Russian policymaking, if the topic is present in the scientific research, if the development strategies and concepts created and implemented are in line with sustainability principles and the implementors are aware of sustainability goals.

As was already mentioned there are some gaps in the scientific research of application of different assessment methodologies in Russia, therefore it is important to analyse these methodologies and to test possibilities for implementation.

The second part of research is devoted to the education for sustainability, and the main aims of this part of the research were to get an understanding of the status quo of the education of sustainability in Russia, to define the sources of integration of sustainability topics into education and to research possible problems and formulate recommendations for strengthening the integration.

To fulfil these aims, following research questions were posed:

1. How are the sustainability topics integrated into education, are there any differences between the integration according to the scientific literature and according to the interviews?
2. What are the incentives for the integration of sustainability, what are the main driving forces?
3. How the integration of sustainability could be strengthened?
4. What barriers are standing in the way of the integration?

Education for sustainability plays crucial role in the rise of sustainability awareness of citizens, and it is important to identify the problems in this areas and search for possible measures that could solve these issues.

1.3 Summary and structure of the thesis

The dissertation is organised into six chapters, the thesis structure is presented in the figure 1.1.

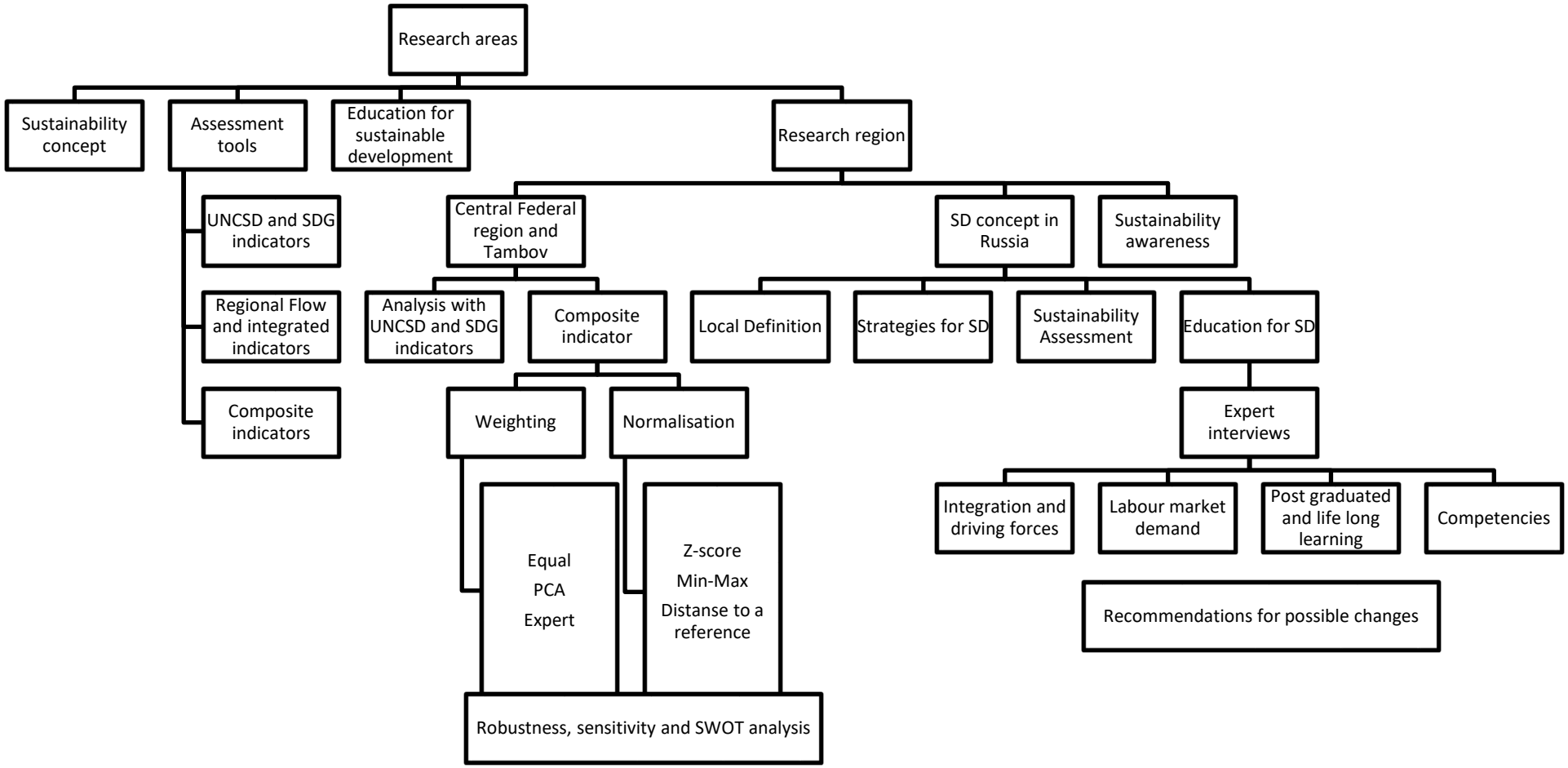
After the short introduction, the second chapter is presenting the results of the literature analysis. In the first two parts of chapter 2 the topics of theoretical concept of sustainability, different assessment methodologies and classification of the assessment tools are presented. Then the different indicators and methodologies for composite indicators development are discussed. In the chapter 2.5 results of literature analysis on the topic of education for sustainable development are presented.

In the chapter 2.6 the research region is presented, and chapter 2.7 devoted to the analysis of sustainability concept in the Russian Federation and comparison Russian scientific literature sources with the rest of the world. The specific Russian strategies and policies for sustainable development as well as assessment methodologies are presented in the chapter 2.7.

Chapter 2.8 and 2.9 are covering the topics of education for sustainable development and sustainability awareness in Russia.

The third chapter of the thesis is devoted to methodology selection, it contains methodologies description and comparison, and research design. The fourth chapter contains results of regional analysis and composite indicators construction. In the fifth chapter the results of the research of the education for sustainability in Russia are presented. The sixth chapter is the discussion of results and recommendations for future research.

Fig. 1.1 Structure of the thesis



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Theoretical background and research framework

Chapter 2 covers the differences in the definitions of sustainability in theory and in practice, as well as in different regions, course, and milestones of development of sustainability common understanding. Different aspects of sustainable development are discussed, with brief overview of the holism of a systems approach, the contrast of weak vs. strong sustainability. It also covers different approaches to sustainability assessment, indicators used to assess development and application of methods to develop composite indicators.

This chapter is an attempt to answer the questions: "What does it mean sustainable? How is it defined in scientific literature? Is the definition different in Russia?"

2.1. Sustainability concept in theory and practice

In the last half of twenties century, four key themes emerged from the collective concerns and aspirations of the world´s people: peace, freedom, development, and environment (WCED, 1987). Over time the meaning of these issues is reinterpreted, but they remain important and lead to creation of different organisations which are trying to propose a strategy to deal with them. Concept of sustainable development is the result of such efforts, it is an attempt to show how the pursuit of one great value required the others (Kates et al., 2016).

Initially the term was used in ecologic and economic literature. Sustainability concept was trying to integrate economic and ecology issues together (concept of sustainable yield both maximum and optimum). The area of coverage was starting from individual species and then it has reached the whole humanity (Adams, 1990).

So it has been more than 30 years since the term "sustainability" has entered with the full force into the deliberations of national and international policy forums, but still the most often quoted definition is from the Brundtland report, in "Our common future" (Felgueiras et al., 2017; Schaefer and Crane, 2005).

The World Commission on Environment and Development was initiated by the General Assemble of the United Nations in 1982, and its report was published in 1987 (WCED, 1987). The conflicts between environment and development were first acknowledged in the 1972 Stockholm Conference on the Human Environment and then it was also discussed in the 1980 World Conservation Strategy of the International Union for the Conservation of Nature (International Union for Conservation of Nature and Natural Resources, 1980). The World Conservation Strategy argued for conservation as a means to assist development and specifically for the sustainable development and utilization of species, ecosystems, and resources (Adams, 1990). Based on these, the Brundtland Commission began its work to the unity of environment and development (WCED, 1987).

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987), this definition includes different dimensions human well-being of the present generation, well-being and needs of future generations and the well-being of people living in other countries. The Brundtland's definition is covering global perspective, by the fact that process of meeting needs of people in one country can compromise the well-being of people living in other countries. Human well-being is a subjective matter, which is difficult to define and there is no theoretical consensus how it could be measured. The well-being will be different for different people and it depends on what they regard as important in their lives (UNECE, 2014).

The main achievement of the Brundtland report was the mainstreaming of sustainable development as a concept that recognizes the systemic interconnections between the needs of environmental protection and of development, making these two problems unsolvable in isolation (Halla and Binder, 2020).

Baumgärtner and Quaas (2010) offer a definition of sustainability as the combination of normative goals for economics, seeking efficiency in the satisfaction of human needs and wants, and sustainability, seeking intra- and intergenerational justice for humans and nature.
Brown et al. (1987) admits that the meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic, or ecological perspective. That is why sustainability can be described broadly or narrowly, but it is highly dependable on the context in which it is used (Brown et al., 1987).
Sustainable development is an activity that permanently satisfies a given set of conditions for an indefinite period of time (Hansen, 1996). That is why when the sustainability strategy development is concerned, there is a need for an adequate set of assessment and monitoring criteria.
To be an effective sustainability assessment tool, the framework must provide up-to-date information about sustainability at multiple scales, from regional to finer scales, such as sub-catchments, as it is widely considered that large differences in sustainability occur across these smaller scales (Graymore et al., 2009).
It needs to be based on local definitions of sustainability to ensure it is measuring things important to the sustainability of the region, as it is a contextual concept with different meanings in different places and to different people (Federal Government of Germany, 2008; Wallis et al., 2007). To be an effective sustainability assessment tool, the framework must provide up-to-date information about sustainability at multiple scales, from regional to finer scales, such as sub-catchments, as it is widely considered that large differences in sustainability occur across these smaller scales (Graymore et al., 2009).

Furthermore, these interactions need to be dynamic and adaptable, "a livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base" (Scoones, 1998). The shift to SD will introduce additional obstacles, such as capacity constraints, disciplinary protectionism, and conflicts with existing institutional arrangements (Jenkins et al., 2003; Lee and Kirkpatrick, 2006).

Moldan et al. (2012) highlight the fact that sustainability and sustainable development is not identical, even though the fundamental sense is basically the same. Sustainability is seen as a system property or quality, when the sustainable development is defined by Brundtland definition (WCED, 1987): "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature". Firstly, the idea of sustainable development is pragmatic and anthropocentric one, as it is primarily focusing on people and human needs (Moldan et al., 2012).
Moldan et al. (2012) compares the concept of Maslow pyramid (Maslow, 1968) to sustainability and at the bottom of sustainability pyramid our needs are located. In the Maslow pyramid unsatisfied needs are seen as motivation for development (Maslow, 1968). According to Maslow (1968) there are several needs (physiological, survival, safety, love, and esteem) that must be fulfilled before person can act unselfishly. Moldan et al. (2012) see this foundation for unselfish behaviour as one of the conditions for accomplishing sustainable development. The principle of living „healthy, productive and in harmony with nature" is leading to the balance between three pillars of sustainability (Moldan et al., 2012).
Another important feature of sustainability is dynamic and log-term nature (Moldan et al., 2012). The Brundtland´s definition is considering "present and future generation" and it points out the continuity of development without any clear target.
This worldview is founded on three general sets of observations regarding the interaction between bio-physical limits and human activity:

1. Renewable resources are being used at rates greater than replacement.
2. Wastes are accumulating faster than our environment can assimilate them.
3. Non-renewable resources are not being used with the long-term implications of their non-renewability in mind: suitable substitutes are not being developed while these resources are still plentiful (Floyd and Zubevich, 2010).

One typically comes across two fundamental, distinct and broad visions of the concept of agricultural sustainability (Hansen, 1996):

- sustainability as an approach
- sustainability as a property.

With sustainability as an approach some practices are seen 'sustainable' while others are not. The result is typically a package of 'good' practice (crop rotation, soil conservation, low or reduced use of fertilizer, pesticide, fossil fuels, etc.) that at least has the advantage of clear definition (Goldman et al., 1996; Penfold et al., 1995). One can monitor progress towards sustainability by simply noting the implementation of 'good' practices.

Sustainability seen as a system property seeks to define the ability of the system to exist in some preferred state and continue to deliver its products over time (Clayton and Radcliffe, 1996). This vision poses more problems in terms of definition and measurement than a simple list of 'good' practice, not least being the need to identify the system boundaries and time scale. The result has been a focus upon the development and application of sustainability indicators (SIs) in much the same way as environmental indicators have been used to assess environmental quality (Bell and Morse, 1999).

In general terms, the idea of sustainability is the persistence of certain necessary and desired characteristics of people, their communities and organizations, and the surrounding ecosystem over a very long period (indefinitely). Achieving progress toward sustainability thus implies maintaining and preferably improving, both human and ecosystem well-being, not one at the expense of the other. The idea expresses the interdependence between people and the surrounding world (Hodge and Hardi, 1997).

There are many interpretations of sustainability, one of the most common conceptualizations is the triple bottom line concept in which sustainability is "presented as the intersection between environment, society and economy, which are conceived of as separate although connected entities" (Giddings et al., 2002). This conceptualization tends toward "weak" form of sustainability, which allow for recompensating of the failures in one domain by the successes in another one (Halla and Binder, 2020). In practice it often leads to the prioritization of economic development at the expenses of other aspects of sustainability (Scerri and James, 2010).

In contrast to the "weak" concept the concept of "strong" sustainability challenges the substitutability between different domains by attributing a unique inherent value to each domain, the advocated of strong sustainability believe than human-made capital and natural capital can only be complementary and are only interchangeable to a limited extent (Davies, 2013; Halla and Binder, 2020; Randall, 2020).

Sustainability is a multi-dimensional concept, and there are controversies in the questions which aspects sustainability should cover as well as which aspects should have priority. At an international level, developing and under-developed countries have so far given priority to social and economic development perspective, in contrast developed countries put ecological issues in the foreground and demand developing countries to take the initiative in solving these problems, where they believe progress can be made at lower costs (Heinrichs et al., 2016).

There are many concepts and opinions on the definition of sustainability, but the main outcome of the sustainability science of the last 30 years is the progress and convergence in understanding of the fundamental building blocks of sustainability. Those building blocks are not just abstract definitions, but more pragmatic features which relate both to normative principles (equity, inclusiveness, and precaution) as well as to other characteristics, such as dynamism, systemic integrations, complexity and value-ladeness (Christen and Schmidt, 2012; Gibson, 2006; Halla and Binder, 2020; Waas et al., 2014, 2011).

There are many interpretations of sustainability, for example Patterson et al. (2017) distinguishes four:

1. Ecological – tend to emphasise the ideas of threshold, the steady state, carrying capacity, interdependence between ecological processes and the idea that the socio-economic system is embedded with the global biophysical system
2. Economic – tend to emphasise the idea of social welfare and the external environmental costs associated with economic activity
3. Thermodynamic and ecological-economic accept the essence of many of the ecological interpretations but go further by situating ecological sustainability in the context of the entropic nature of economic-environmental interactions
4. Public policy and planning theory approaches to sustainability emphasise the social, institutional, economic, and environmental aspects of sustainability within a framework that seeks to achieve a "balance" of an "integration" of these factors.

Across many of these interpretations there is a need for quantitative indicators to take account of the system-wide effects in addition to on-site environmental impacts (Patterson et al., 2017).

The United Nations (UN) is the principal initiator and driver of sustainable development at the international level, starting with the UN Conference on the Human Environment, Stockholm in 1972, where the international community agreed that both development and the environment could be managed in a mutually beneficial way (United Nations, 1972; Villeneuve et al., 2017). The Stockholm conference was remarkable in that it forcefully revealed a rift between the needs of developing and developed countries, particularly concerning the issue of how to balance environmental protection against the urgent need for poverty reduction (Halla and Binder, 2020). That conference was the occasion for the international community to adopt virtuous principles to be integrated in development policies, strategies, programs, or projects. Acknowledging the difficulty of such questions led to a setup of an independent commission to investigate how to solve those problems (Halla and Binder, 2020).

This approach led to the adoption of Agenda 21 at the UN Conference on Environment and development held in Rio de Janeiro in 1992 (Villeneuve et al., 2017).

The political interest in sustainable development slowly waned and according to Holden et al. (2017) hit its bottom at the unsuccessful 2002 UN World Summit on Sustainable development in Johannesburg. Sustainability did not enter the realm of decisions makers sufficiently, to prevent multiple crisis (food, climate, water, poverty, etc.) that accumulated with the 2008 financial crisis; in response the United Nations Conference on Sustainable Development "Rio+20" in 2012 led to the call of a new Agenda for 2030 to face those challenges (Villeneuve et al., 2017). Some of the researchers admit that the 2012 Rio Summit led to a "rebirth of sustainable development" (Dodds et al., 2014).

The conferences had aimed at revival and strengthening commitment to sustainable development, ascertaining failures and identification of reasons, recognition of achievements, setting priorities and determination of problems, that had not been addressed sufficiently before (United Nations, 2020).

Since 2015 global sustainability policy is guided by the agreement reached at the twenty-first session of the Conference of the Parties (COP) in Paris (Robbins, 2016). The Paris Agreement is based in the timeframe 2015-2030 and articulates the fundamental ethos of sustaining human life without harming the planet or humanity (Kelman, 2017). It aims at holding global warming to well below 2 degrees Celsius and to pursue efforts to limit it to 1,5 degrees Celsius (UNFCCC, 2015). And this climate goal represents the level of climate change that governments agree would prevent dangerous interference with the climate system, while ensuring sustainable food production and economic development (Knutti et al., 2015; UNFCC, 1992).

Paris agreement have initiated a new round of discussion of the national priorities and burden sharing, also some scientists are stating that the 2 Degree limit has no scientific base and no scientific assessment has clearly justified of defended the target as a safe level of warming (Knutti et al., 2015).

From one side the adoption of Paris agreement brought all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects for the first time (UNFCCC, 2015), but from the other side there are many issues that have been raised during the first round of INDCs (Intended Nationally Determined Contributions) (Rogelj et al., 2016). According to Rogelj et al. (2016) these include the equality of distribution of efforts among countries, required adaptation given the current level of mitigation ambition, implementation of the intended national proposals; the financing of the measures and the extent to which the implementation of the INDCs could contribute to other UNFCCC aims – for example sustainable development.

At the United Nations Conference on Sustainable Development, held in Rio de Janeiro in 2012, the member states agreed to develop a set of SDGs that should succeed the UN Millennium Development Goals (MDGs) established in 2000. While MDGs were geared mainly towards developing countries, the SDG applied to all nations (Schmieg et al., 2018). SDGs are unprecedented and unique, they are developed by UN member nations, and adopted by 190 countries, these 17 goals and 169 targets identify global development priorities, effectively defining sustainable development through selected targets (Wackernagel et al., 2017). Those targets provide measurable benchmarks that in return allow observers to test progress against each target (United Nations, 2015a).

SDGs have received some criticism too, one of the points that has been criticized is the fact that the goals are not prioritized and there is a risk of running satisfied with achieving secondary goals while simultaneously failing to achieve primary goals (Holden et al., 2017; Spaiser et al., 2017).

Another problem highlighted in the literature is the fact that some of the goals are not quantifiable, for example the environmental Goals (12-15) are merely ambitions to "Protect", "Strengthen" and "Promote" (Holden et al., 2017; ISCU, 2015; Stafford-Smith, 2014). According to the report of the International council for Science (ISCU, 2015) out of 169 targets, 49 (29%) are considered well developed, 91 (54%) could be strengthened by being more specific, and 29 (17%) require significant work. Even with the quantifiable goals the measurability will depend on the availability of the data and capacity to collect reliable data (ISCU, 2015). The SDG framework pose conceptual as well as implementation challenges that will require enhancing the close collaboration between the policy and scientific communities as well as other stakeholders (ISCU, 2015).

Another issue which is pointed out by the scientists is the missing of a "narrative of change", in terms of how the pursuit of specific goals would lead to broader outcomes of social change and in terms of how this change actually takes place (Costanza et al., 2016). There is a need to enable a more systematic means-ends separation between ultimate goals and enabling means and conditions, and a need for more technical work to demonstrate the way in which goal implementation can induce social change (ISCU, 2015).

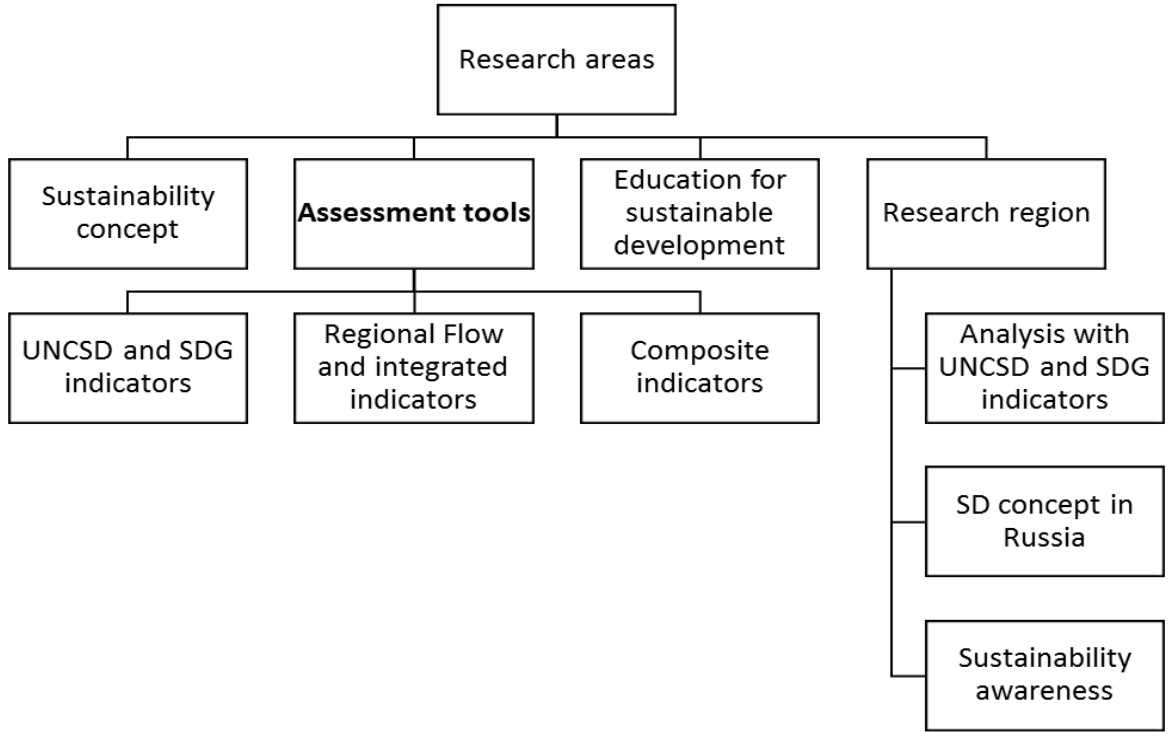
Setting of the ultimate goal is problematic due to the fact that there is no consensus of how the sustainable well-being should look like, how to measure it and how to achieve it (Costanza et al., 2014). The goals are presented using a "silo approach", meaning they addressed as separate elements, ignoring the fact that goal areas could overlap or thar many targets might contribute to several goals and that some goals may conflict (ISCU, 2015). Developing interlinking targets would enable trade-offs to be mitigated and synergies emphasized (ISCU, 2015).

Some of the researchers admit that by many measures, human activities today are even further from sustainable levels than they were when sustainable development first found its way onto the public agenda (Halla and Binder, 2020; Millennium Ecosystem Assessment, 2005; Steffen et al., 2015). It could be seen that there is an on-going work in the area of solving problems concerning sustainability, but success of the global measurements will depend heavily on capacity of countries to develop and implement programmes of action to address their climate and development objectives in an integrated, coordinated and comprehensive way (Gomez-Echeverri, 2018).

2.2 Sustainability assessment tools

As one of the aims of this research is to develop a suitable methodology for the sustainability assessment it is important to perform a literature review of available tools to assess sustainability.
Policy decision making is a very complex thing, and when the decisions are assessed in terms of sustainability there are many interlinkages which should be considered, and it is not always easy to predict the results of certain decisions. That is why it is important to make sure that a region or a country is taking the right pass of development.
Nowadays no standard procedure exists for the assessment of sustainable development (Bond et al., 2012; Halla and Binder, 2020; Pope et al., 2017a). Nevertheless, there is a need for a tool, which can measure if the policy decision is contributing to the sustainability or not (Becker, 2005; Pope et al., 2017a). This tool should follow an integral systematic approach to the definition and measurement of problem, in order to give well-structures methodologies, easy to reproduce and to assure that all important aspects are included in the measurements (Singh et al., 2009). Integral systematic approach is important in case of sustainability, because of the complex nature of sustainability concept. Assessment of sustainability could lead to meaningful results only when the studied region or enterprise are accepted as a system, which has a lot of components, which are interacting and influencing each other. In the best case systematic approach should be not only measuring a current state, but it should be trying to answer the question how to make system more vital and sustainable (Bossel, 1999).

Fig. 2.1 Linkage of the chapter to the overall structure of the thesis.



Source: own illustration

2.2.1 From a definition to a practical tool

It becomes a very complex task to assess sustainability at policy level and its complexity starts at the very beginning – during the definition of the term.
The origins of the modern sustainability concepts are often associated with the activities of Club of Rome in 1970th (Meadows et al., 1972; Neckel, 2017; Siche et al., 2008), the book "Limits to growth" pointed out the serious problems that humanity should solve to overcome an ecological and social disaster (Meadows et al., 1972). Among the critical problems they cited were: the

intensive use of fossil energy with the consequent end of reserves; reduction of supply of natural resources; increment of the industrial activity and pollution; increase and collapse of population; and, the limitation of the capacity of food production (Meadows et al., 1972). The term "sustainability" was introduced as an international issue by the book "The World Conservation Strategy" in 1980 (IUCN et al., 1980).

The most popular definition was stated in Brundtland report (WCED, 1987) but it is not offering manageable guidelines for sustainability strategies decision-making bodies; such instructions only could be created with specific indicators and quantitative values (Nijkamp and Ouwersloot, 1997). Sustainability assessment (SA) is defined as a process that operationalizes sustainability and integrates it into decision-making process, it can take a wide variety of possible forms and it covers many possible decision-making situations (Halla and Binder, 2020). The theme of sustainability assessment is broadly presented in the scientific literature, there are many attempts to create an assessment framework for sustainability (Bond et al., 2012; Gibson, 2006; Pintér et al., 2012; Pope et al., 2017a; Sala et al., 2015; Waas et al., 2014). The scientific articles could be divided into two groups the first one is descriptive and is describing what SA currently is, the second group is prescriptive and prescribing what SA should be. The SA mainly operates on abstract principles and concrete applications are defined contextually and on a case-by-case basis (Halla and Binder, 2020).

According to Boulanger & Brechet (2005) there are three main reasons why the policymaking on sustainability issues constitutes a special type of decision-making.

First, the way to such development is starting from the decision-making process during which the goals and objectives should be defined. It is again coming back to the definition of sustainability, which sometimes can be interpreted in different ways. That is why before starting to choose the policy to achieve such development, policymakers are supposed to clarify the question what sustainability means in this specific case (Boulanger and Bréchet, 2005; Granco et al., 2019).

Choosing sustainable development goals involves normative judgement therefore sustainability assessment can never live up to the scientific standards of the natural science (United Nations department of economics and social affairs, 2014).

Second reason is the fact that there is not only single decision-maker, but plurality of them, and each with his own preferences, beliefs and interests (Ridder et al., 2007). From the other side, the assessment of the costs and benefits is more difficult than for normal business (Boulanger and Bréchet, 2005). Since the sphere of influence of the policy decisions are broader compared to the decisions, which are related to sustainability of different companies.

The third reason could be explained with three key features, which are inherent in all sustainability issues: the existence of externalities (spatial, intertemporal, social); the existence of uncertainties; the interplay between human and nature.

Externalities occur when some group of people do not bear the full cost of the development, but pass it to another group, which spatially, chronologically or socially distant, without sufficient compensation (Boulanger and Bréchet, 2005).

The uncertainties are directly connected to the time frame for which the decisions are taken. In the long run the risks that the cost-benefit ration could change are higher.

The third factor is interplay between human and nature, by some authors it was treated as the most important meaning of sustainability. For example, Van den Bergh and Hofkes (1998) wrote: "Although the precise definition of sustainable development is subject to different interpretations, it is generally agreed that it refers to the long-term mutual interdependence between resource availability and environmental quality on the one hand and a stable economic development on the other hand". It is forcing policymakers to find this fragile balance between sufficient level of development and preservation of nature.

According to Boulanger & Brechet (2005) each feature requires a specific methodological answer; these features are presented in Table 2.1.

Table 2.1 From sustainability problem to methodological answers

Problem	**Methodological answer**
Human-nature interaction	Interdisciplinary approach
Uncertainties	Uncertainty management
Temporal externalities	Long range view
Spatial externalities	Local-global perspective
Social externalities	Stakeholders' participation

Source: Boulanger and Bréchet, 2005

To deal with the sustainability issue the methodology should be interdisciplinary. The need for it is coming from the so-called "three pillar" or "triple bottom line" concept that has become common (Rorarius, 2007). The economic, social and ecological issues should be included in one theoretical framework therefore different variables and statements should be integrated (Boulanger and Bréchet, 2005; Ramos, 2019). That means that disciplines such as economics, management, ecology, social and political sciences must be included. These disciplines should be not only included, but they should be also interconnected. The sustainability assessment is a kind of an integrated assessment which tries to include the sustainability concept into the decision-making (Pope, 2006; Rau et al., 2018).

Modelling of sustainable development is strongly connected to different uncertainties. Boulanger & Brechet (2005) are claiming that there are three main uncertainties:

- uncertainty about a model's quantities – during the modelling the parameters which are determining the sustainability of development should be chosen and the initial condition of these parameters should be stated
- uncertainty about the model structure (the relation between variables, functional forms, casual influences, delays, etc.); model is an attempt to simulate the possible outcome of the decisions, to get the realistic picture of the relation between the variables and the functionality of them, and it should be interpreted in the way which is the closest to reality
- uncertainty about a model's pertinence (level of granularity, selection of variables, closeness, time scale).

Sensitivity analysis and standard statistical methods are helping in dealing with the first type of uncertainties (Becker et al., 2017; Tan and Lu, 2016). For the two other uncertainties the improvement of scientific knowledge is needed, with the help of more detailed information the model could be transferred from the black box to the white box.

By the long-term perspective is meant that the various time span should be fully integrated into the model to allow the unfolding of the systems complete dynamics – for example natural cycle or business cycle (Boulanger and Bréchet, 2005; Costa et al., 2019).

Due to spatial externalities the local-global perspective should be also included (Boulanger and Bréchet, 2005; Shi et al., 2019).

Participation is a crucial part for the sustainable development, it is important to involve the stakeholders at the very beginning to give them a chance to integrate their values and objectives into the future model (Becker, 2004; Brombal et al., 2018). Participation serves the inclusion of stakeholders in assessment process, it provides the room for political discussion of different points of view, it gives an opportunity for policy learning and building capacities (Berger, 2007). Pinter

et al. (2012) also highlights that the assessment should find appropriate ways to reflect the views of the public.
For example, in frames of development program in the Baden-Wurttemberg region of Germany the ideas and initiatives for the possible projects are coming from the citizens of the supported areas (Ministerium für ländlichen Raum und Verbraucherschutz Baden-Württemberg, 2013).
Pinter et al. (2012) states 5 more procedural requirements for SA, apart from participation and adequate scope:

1. Guiding vision – assessment of progress toward sustainable development should be guided by the goal of delivering well-being within the capacity of the biosphere to sustain it for future generations
2. Essential considerations – the assessment should consider the underlying social, economic, and environmental system as a whole and the interactions among its components, including issues related to governance, dynamics, drivers, risks and uncertainties, and cross-boundaries
3. Framework and indicators – the indicators should be identified within a conceptual framework, standardized measurement methods should be used, and the indicators should be compared with aims
4. Transparency – the data, indicators and results should be accessible to public, the choices, assumptions, and uncertainties should be explained, the data sources should be disclosed, as well as all sources of funding and potential conflicts of interests
5. Effective communication – the communication should use plain and clear language, it should present information in a fair and objective way, it should use innovative visual tools and graphics, it should make data available in as much detail as is reliable and practicable
6. Continuity and capacity – assessment should include repeated measurement, responsiveness to change, investment to develop and maintain adequate capacity, continuous learning, and improvement.

Halla and Binder (2020) admit that the SA is not a specific tool, but it should be considered as "a forum for engaging with the value-laden and complex topic of sustainability" and potential of SA lies in the facilitation of a connection between expert defined sustainability facts and the contextual everyday reality.
As was already mentioned there is no standard procedure to evaluate the sustainable development. Graymore et al., (2009) argues, that the reason for the absence of such framework is the complexity of interrelation of human and nature systems. These systems comprise different properties and they are heterogeneous in their nature, but in the early 90th it was already clear that a tool is needed, which can provide guidance in the political decision-making.
From the very beginning it was clear that it is a complicated task, and many international organisations were working on it. The organisation of United Nation organised a special commission to work on this issue (UN system task team, 2013). European commission and OECD have funded several scientific projects which aimed at the creation of suitable set of instruments for sustainability assessment (MATISSE 2005-2007, SAMT 2015-2016).
An important part of the assessment process is the setting up the assessment criteria, the indicators and indexes became a core of this process at all levels: local, national, regional and global (Campagnolo et al., 2018).

2.2.2 Classification of sustainability assessment tools

During last 20 years the number of tools, which claim that they can assess sustainability, have grown and different scientist have made attempts to classify this tools (Halla and Binder, 2020; Ness et al., 2007; Ridder et al., 2007; Rorarius, 2007).
Classification made by Ness et al. (2007) contains three groups of methods: indicators and indices, which are further broken down into non-integrated and integrated; product-related assessment tools with the focus on the material and/or energy flows of a product or service from a life cycle

perspective, and integrated assessment, which are a collection of tools usually focused on policy change or project implementation.
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Rorarius (2007) divides all methods into two big groups – indicators/indices and assessment tools. Assessment tools are also divided into product-related, project-related, sector and country related and sustainability assessment.
In the table 2.2 the compilation of the two classifications is presented. The methods are divided into the same groups as presented by Rorarius (2007) and afterwards indicators and assessment tools are also classified by the dimension: environmental, economic, social, integrated, or sustainable development. It indicates which analysis method emphasize and correspond to specific dimension. Integrated tools are capable of integrating nature-society systems into single evaluation (Ness et al., 2007).

Table 2.2. Classification of assessment tools

Dimension	Indicators	Assessment tools	
		Project-related assessment	Sector and country related assessment
Environmental	Environmental pressure indicator Ecological footprint Environmental sustainability index	Environmental impact assessment Environmental risk analysis	Environmental extended input-output analysis Strategic environmental assessment
Economic	Gross national product	Full cost accounting	Economy wide material flow analysis Economic input-output analysis
Social	Social indicators	Social impact assessment	Social input-output analysis
Institutional			
Integrated	Sustainable national income Genuine progress indicators and ISEW Adjusted net savings Wellbeing index / HDI	Conceptual modelling System dynamics Multi-criteria analysis Risk analysis	Uncertainty analysis Vulnerability analysis Cost-benefit analysis
Sustainable development	UNCSD 58		SIA/ISA

Source: adapted from Rorarius 2007 and Ness et al. 2007
There is also a difference between integrated and sustainable development dimension. The first is analysing each aspect of sustainability separately and the second all together. Assessment tools are also classified into two smaller section: project-related assessment and sector/country related assessment (Rorarius, 2007).

The environmental impact assessment is associated with the assessment of particular projects, when strategic impact assessment refers to the assessment of longer-terms plans, programs and policies (Pope et al., 2017a). After the introduction of EIA and SEA the concept of sustainability assessment (SA) was introduced (Bond et al., 2012). Pope et al. (2017) admits that "the defining feature of sustainable assessment compared with other forms of impact assessment is that some attempt is made to engage with the concept of sustainability in all its complexity".
The classification of Rorarius (2007) and Ness et al. (2007) are complementing each other, and they are based on the same concept of classifying the tools. Another insight is presenting the classification of Ridder et al. (2007); the scientists offer to divide all tools into seven groups: assessment frameworks; participatory tools; scenario analysis tools; multi-criteria analysis; cost-benefit and cost-effectiveness analysis; accounting tools, physical tools and indicator sets; model tools.
Into the group of assessment frameworks are included the sustainability impact assessment and integrated impact assessment. Those frameworks are not tools themselves, but they are procedures, which are connected to decision-making process and many analytical tools could be used within this frameworks (Ridder et al., 2007).
It is interesting that Ridder et al. (2007) is making a separate group for participatory tools. It underlines the importance of the tools in the integrated analysis of sustainability. These tools are using the knowledge of non-experts to articulate their preference, values and experiences (van Asselt Marjolein and Rijkens-Klomp, 2002).
Scenario analysis include tools for defining scenarios, developing scenarios and interpreting the results (Ridder et al., 2007). Scenarios are constructed specially to assist in the understanding of possible future developments of complex systems. This group can include Delphi method, cross-impact analysis and many more (Börjeson et al., 2006; Schwartz, 1996).
Cost-benefit analysis is covering all the methods, which are helping to find out monetary value of positive and negative effects of policy decisions (Ridder et al., 2007).
There is a range of methods, which can be used to assess sustainability. Different scientists are trying to classify all available tools to make it clearer in which case which tool should be used, but it is not always an easy choice. For example the experience of impact assessment in European Union is showing, that tool´s choice is often determined by data, time and budget availability and by the experience of IA users (Ridder et al., 2007).
Scientific research often differs from the policy-making practice, but still in both situation the framework of sustainability analysis requires following components (Nijkamp and Ouwersloot, 1997): measurable sustainability indicators; normative reference values (carrying capacity or critical load); practical impact methodology for assessing future developments (because of changes in behaviour, exogenous development, or policy orientation).
It means that for the assessment of sustainability the framework should combine indicators and impact methodologies. The indicators have a retrospective character, and the impact assessment techniques are of prospective and forecasting nature.

2.3 Indicators of sustainability

The first group of tools, which could be used for assessment of sustainability, are indices and indicators. Indicators are simple measures most often quantitative that represent a state of economic, social, and environmental development in a defined region – often the national level or at the enterprise level. When indicators are aggregated in some manner, the resulting measure is an index (Ness et al., 2007).
Indicators and indices are not only used in scientific world, but they are also popular in different competitive rankings for examples in sports tables or university ranking. Also some highly aggregated indicators are popular, for example, Human development index is providing a quick comparison of countries based on such ranking (Moldan et al., 2012).

Over recent decades, indicator-based projects have become central to a broad range of community development and policy-oriented social research, especially with an aim of assessing sustainability (Scerri and James, 2010). Indicator´s use in sustainability assessment has gone the way from attempts to analyse sustainability with help of limited available data to the phase when the main difficulty is the selection, interpretation and the use of indicators (Moldan et al., 2012).
The set of indicators is serving an aim to simulate the representation of the reality, which allows measurements and calculations. But the system of indicators usually does not give an opportunity to explain the reasons of the phenomena (Todorov and Marinova, 2011). According to Yunis (2004), "they are signals of current issues, emerging situations or problems, need for action and results of actions". Dahl (2012) also admits, "where the indicators are updated and reported regularly, they provide clear signals on the success or failure of national policy initiatives and actions ".
Sustainability is a complex concept that covers a lot of different aspects and direct measurement of it is not possible. Instead "alternative measurements" – indicators covering different dimension are required (Olsson et al., 2009).
Olsson et al. (2009) underlines, that indicators are not only serving an aim to measure sustainability level but also can be a guide "for how to comprehend the concept of sustainable development". Some authors even consider the assessment of the impact of a new policy, using a set of indicators as a prerequisite for the implementation of sustainable development (Ledoux et al., 2005).
In general indicators could be used to report findings to decision makers and other stakeholders; to monitor changes over time and identify failures and progress in development; to guide policy planning and preparation of political decision (Zeller et al., 2006).
Nevertheless, indicators mostly succeed in evaluating unsustainable trends, but there are insufficient in defining or ensuring the sustainability (Dahl, 2012).
Singh et al. (2012) gave an overview of various SDI and grouped them into the following categories: innovation, knowledge and technology indices; development indices; market and economy based indices; eco-system based Indices; composite sustainability performance indices for industries; product based sustainability index; sustainability indices for cities; environmental indices for policies, nations and regions; environment indices for industries; social and quality of life based indices; energy based indices; ratings. Additionally, the classification and evaluation of SDI can be done based on the following dimensions: aspects of the sustainability to be measured by indicators; techniques used for development of index like relative or absolute, quantitative or qualitative, unidimensional or multidimensional; measurement of sustainability in terms of input (i.e. means) or output (i.e. ends); clarity and simplicity in its content, purpose and method; availability of data (Singh et al., 2012).
There are several criteria of the indicator´s effectiveness: scientific credibility, salience in addressing need to potential users, perceived legitimacy and timely availability of indicator data (Lehtonen, 2008; Zeiger et al., 2019).
According to Dahl (2012) the challenge of sustainability assessment is in the finding of indicators of change in dynamic systems, establishing sustainability targets towards which national progress can be measured, developing global level indicators. At the end indicators should become a reflection of progress in development and a positive incentive for further efforts (Dahl, 2012).
According to Gomez-Limon and Sanchez-Fernandez (2009) the conceptualisation of sustainability presents problems regarding its operational concretisation, because to assess sustainability we must analyse the future production and we need to identify specific demands which should be satisfied by that production. To overcome those difficulties the empirical evaluation of sustainability should be based on the triple dimension of economics, social justice and environmental friendliness (Gómez-Limón et al., 2020). Gomez-Limon and Sanchez-Fernandez (2009) and Bell and Morse (2008) see a great potential in indicators to embrace each of the above-mentioned dimensions.
The array of sustainability assessment tools is broad and Bell and Morse (2008) allege that "now we have developed so many indicators that we are having to ask ourselves, what exactly are we

measuring" (Bell and Morse, 2008). Some authors admit the despite the variety of available sustainability indicators an absence of a commonly accepted categorization framework often creates confusion and inhibits indicators deployment (Park and Kremer, 2017; Saidani et al., 2019)

2.3.1 UNCSD and SDG indicators

One of the most popular frameworks for indicator´s use is the methodology created by the commission of sustainable development of United Nations organisation. The history of development of this methodology gives an opportunity to follow the changes in the conceptual structure of the sustainability issues. The system of methods was changing as a response to the evolution of scientific findings.

The United Nations Conference on Environment and Development held in 1992 recognized the important role that indicators can play in helping countries to make informed decisions concerning sustainable development (United Nations Commission on Sustainable Development (UNCSD), 2007) and commission of sustainable development (CSD) started the work on the development of suitable indicators. These indicators have been extensively tested, applied, and used in many countries as the basis for the development of national indicators of sustainable development.

In 2002 new set of CSD indicators was developed (United Nations Commission on Sustainable Development (UNCSD), 2007) and it encouraged further work on indicators on country level. The revised set of CSD indicators, which were published in UN guidelines in 2007, consists of 58 indicators. In the table 2.3 the indicators' themes are presented.

These indicators were not strictly following the three pillars concept of sustainability but trying to move to the multi-dimensional and integrated approach. For example, poverty and natural hazards were offered as cross-cutting themes.

In 2015 the 17 Sustainability development goals were set by the United Nations General Assembly (General Assembly of United Nation, 2015). Each goal has a list of targets that are measured with indicators, which are classified in three tiers based on their level of methodological development and the availability of data at the global level: the first two tiers are the conceptually clear indicators with developed methodology, but for the first group the data is available for at least 50 percent of countries, for the second group of indicators the data is not regularly produced, the third tier includes indicators for which no internationally established methodology or standards are yet available (General Assembly of United Nation, 2019; Lafortune et al., 2018).

Table 2.3 CSD indicator's themes

Social	***Ecological***	***Economic***
Poverty	Natural hazards	Economic development
Governance	Freshwater	Global economic partnership
Health	Atmosphere	Consumption and production patterns
Education	Land	
Demographics	Oceans, seas, and coasts	
	Biodiversity	

Source: UN, 2007

As of 22 May 2019: The updated tier classification contains 104 Tier I indicators, 88 Tier II indicators and 34 Tier III indicators. In addition to these, there are 6 indicators that have multiple tiers (different components of the indicator are classified into different tiers) (General Assembly of United Nation, 2019).

The SDGs have been criticized for being too ambitions, universal, expansive and with potential inconsistencies, particular between the socio-economic development and environmental sustainability goals (Bali Swain and Yang-Wallentin, 2020; Easterly, 2015; ICSU and ISSC, 2015; UN SDSN, 2015). And the question of measuring the progress towards SDGs lies still open, there are several publications in the emerging literature in this area: the publication of Green Growth Knowledge Platform about measuring the inclusive Green Growth at the country level (Narloch et al., 2016); the SDG Index and Dashboards Global Report prepared by the United Nations Sustainable Development Solutions Network (UNSDSN) and the Bertelsmann Stiftung (Lafortune et al., 2018); and the Overseas Development Institute Report (Nicolai et al., 2015).
GGKP report on measuring Inclusive Green Growth at the country level is not limited to the SDGs and focuses on the Inclusive Green Growth and their interaction in a dynamic perspective (Bali Swain and Yang-Wallentin, 2020).
The Overseas development Institutes report developed a grading system for each of the SDGs (Nicolai et al., 2015).
The report presented by UNSDSN identifies multiple indicators from the most recent published to measure the SDG goal, employing geometric and arithmetic averages, it computes scores for the data across all indicators that apply to each SDG. The method enables them to calculate a country score for each of the 17 goals, on the base of these scores an overall SDG Index is calculated for each country (Lafortune et al., 2018).
Bali Swain and Yang-Wallentin (2020) are admitting that those frameworks are giving a possibility to monitor sustainale development and SDGs, but they are restricted by major data limitations and they do not inform the policy makers on which of the underlying economic, social or environment pillars are significant on impacting sustainable development.

2.3.2 Regional flow and integrated indicators

According to Ness et al. (2007) UNCSD indicators are non-integrated, also he offers too more groups of indicators: regional flow and integrated indicators.
Regional flow indicators have an aim of an overview of a structure of resources flows and identification of inefficiencies within a system. These indicators maybe used for reconstructing historical flows and emissions, for forecasting and decision support (Ness et al., 2007) Regional flow indicators are also non-integrated as they only focus on one aspect of sustainability. For example, material flow analysis (MFA) covers “the physical metabolism of society” to reduce environmental losses. Economy-wide MFA is analysing input, output and consumption patterns of the economy (Ness et al., 2007).
Integrated indicators are the results of attempts to move beyond the non-integrated and combine different nature-society dimension in one indicator or index. The first four indices in the framework (sustainable national income, genuine progress indicator and ISEW, adjusted net savings, ecological footprint) are attempts to develop alternatives to the national accounting indices such as Gross Domestic product (GDP) and Net National Product (NNP), which are often used as measures of overall human welfare (Ness et al., 2007). Level of GDP has been used as a measurement of economic progress and sometimes it has been considered in terms of sustainability, but there is a discussion going on that there is a need to move beyond GDP when measuring economic and social performance (Costanza et al., 2016, 2009; Kubiszewski et al., 2013; Stjepanović et al., 2017).
These integrated indicators are trying to include such critical factor as income distribution, public safety, resource over-utilization and others which are neglected in the common measures (Gerlagh et al., 2002). Each of these indicators is providing a different measurement of sustainable development.
Sustainable National Income is an index developed for the Netherlands (Hueting and Boer, 2001). The tool attempts to move beyond strict economic output parameters to determine well-being by incorporating sustainable resources utilization measurements into national income accounting (Ness et al., 2007). The gap between sustainable national income and conventional national income

accounting practices describes the dependence of the country on natural resource use that exceeds sustainable utilization (Gerlagh et al., 2002).
The index of sustainable economic welfare subtracts from the Gross Domestic Product consequences of economic activity that have negative environmental impacts and adds to the GDP the value of significant activities such as unpaid domestic labour, which is based on the average domestic pay rate (Olsson et al., 2004). The ISEW encompasses the costs of air pollutions, depletion of natural resources, costs of climate change due to greenhouse gas emissions, value of ozone depletion, concerns about unequal income distribution and other effect, which are not contributing to the welfare (some health and educational expenses). It is a highly ambitious index but as with GDP the ISEW bundles together a tremendous amount of information thus leading to a lack of transparency (Olsson et al., 2004).
The genuine savings indicator also called adjusted net savings is actively promoted by the World Bank (Hueting and Reijnders, 2004). Pearce et al. (2001) have defined genuine savings as the savings term of a version of environmentally adjusted net national income, which includes adjustments for damages, compensation, and depletion. The Adjusted Net Saving rate encompasses resource depletion and environmental degradation, and has also been extended to include technological change, human resources, exhaustible resource exports, resource discoveries and critical natural capital. Most emphasis is placed on the economic and environmental components, but the tool also includes investments in education (Ness et al., 2007). A positive indicator value reflects a positive transition towards sustainability when a negative indicator value represents the opposite.
The ecological footprint is an accounting tool that estimates the resource consumption and waste assimilation requirements of a given population or economy in terms of a corresponding land area (Ness et al., 2007).
The Well-Being Assessment by Prescott-Allen (2001) assumes that a healthy environment is necessary for healthy humans. Accordingly, the Well-Being Index (WI) is the arithmetic mean of a Human Well-being Index (HWI) and an Ecosystem Well- Being Index (EWI). The indices HWI and EWI in turn consist of five sub-indices. The HWI comprises a Health and Population, Welfare, Knowledge, Culture and Society, as well as an Equity Index. The EWI comprises indices for land, water, air, species, and genes as well as for resources deployment. The five dimensions of the HWI are based on 36 indicators, those of the EWI on 51 indicators (Prescott-Allen, 2001).
The environmental sustainability index quantifies the likelihood that a country will be able to preserve valuable environmental resources effectively over the period of several decades (Esty and Porter, 2005). It measures “overall progress toward environmental sustainability” (Centre for International Earth Science Information Network, 2005). It consists of 68 indicators of five different categories:

- the state of environmental systems (air, water, soil, ecosystems, etc.)
- reducing stresses on environmental systems
- reducing human vulnerability to environmental change
- social and institutional capacity to cope with environmental challenges
- the ability to comply with international standards and (Centre for International Earth Science Information Network, 2005).

Although, this index focuses mainly on ecological side of sustainability it also comprises some social and institutional issues (Ness et al., 2007).
Since 1990 the Human Development Index (HDI) is reported annually as part of the Human Development Report of the United Nations Development Program (United Nations development programme, 2005). The index contains three general parameters: longevity – life expectancy at birth; knowledge – combination of the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio; standard of living – GDP per capita (United Nations development programme, 2005).

The HDI excludes the ecological parameters, but it is still used to make a comparison between different countries. Although the HDI only partially covers the economic and social dimension of development, this measure is a useful first proxy in the assessment of progress, especially for countries, where more advanced studies are not available (Shmelev, 2011).

2.4 Methodologies and practices for composite indicators development

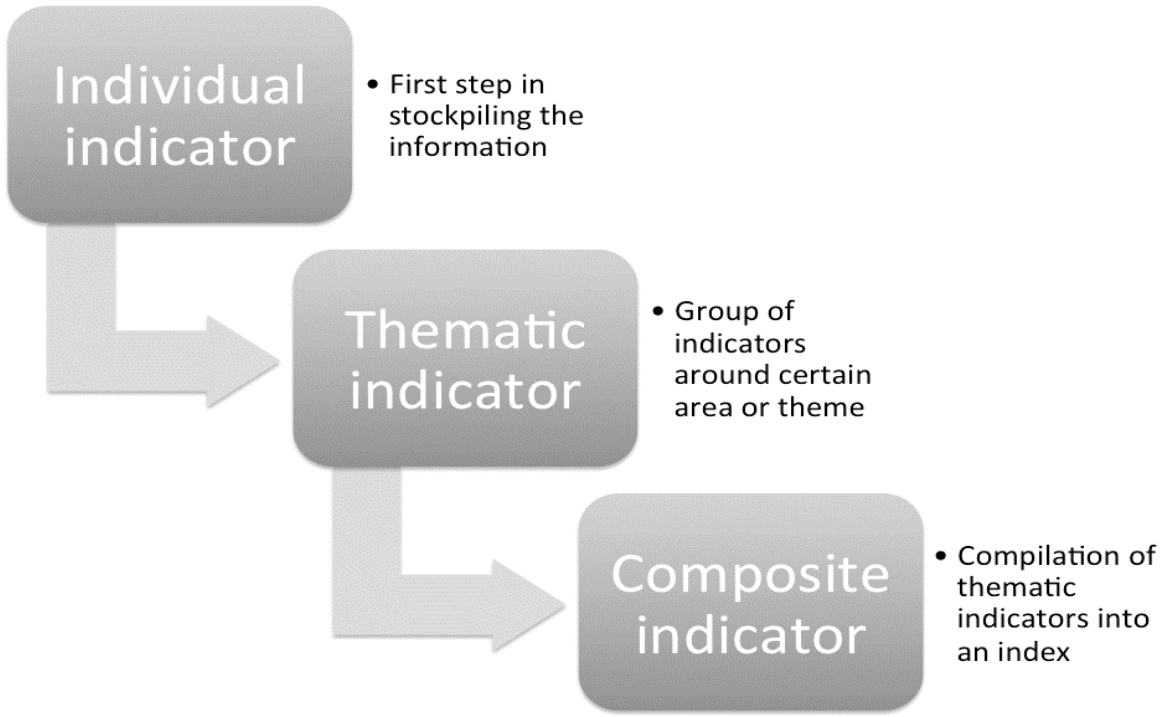
There is a wide consensus in the literature that quantified measure in form of indicators and indices is needed to design a policy leading to more sustainable regional development (Gómez-limón and Sanchez-fernandez, 2010).

UN CSD indicators framework is an example of a detailed sustainability assessment framework. Such large indicator set has an advantage of covering most important developing issues and providing detailed insights. Unfortunately due to high number of indicators the set is difficult to interpret and is not always suitable for informed decision-making (Gómez-limón and Sanchez-fernandez, 2010; Kemmler and Spreng, 2007). That is why aggregation question arise when the sustainability of policy should be assessed or when the sustainability level should be compared between two or more policies (Bockstaller et al., 2009). To make the level of sustainability more observable composite index or aggregated indicator is used, there are a lot of examples in the scientific literature (Freudenberg, 2003; Mazziotta and Pareto, 2016; Mishra, 2008; Qiu et al., 2007)

According to Gómez-limón and Sanchez-fernandez (2010) from the research it is possible to conclude following: there is wide consensus that quantitative measurement of sustainability through indicators and indices is a prerequisete for the adequate design, implementation and monitoring of development policies; from methodological point of view the literature shows exess of techniques to build composite indices; nevertheless all the methods should be used with caution as any of the appoaches should be regarded as partial representations of a complex reality.

In the figure 2.2 the sequence of composite indicators creation is presented. The set consisting of individual indicators is grouped around certain area or themes, and after that composite indicators are formed out of thematic indicators (COIN, 2019).

Fig. 2.2 Composite indicators creation



Source: COIN (2019)

For example, at first the statistical data for an individual indicator measuring the average level of income of the certain region is collected, then this data is mixed with other individual indicators assessing the poverty theme. At the next stage out of different thematic indicators – poverty, education, demographics, etc. a composite indicator for the social development is created.
Following definition of composite indicator was presented at the Inter-Service consultation meeting of the European Commission held in Brussels on March 14th 2002: „Composite indicators are based on sub-indicators that have no common meaningful unit of measurement and there is no obvious way of weighting these sub-indicators“ (Saisana and Tarantola, 2002).
According to Gómez-limón & Sanchez-fernandez (2010) composite indicators are enabling to: summarise the information provided by sub-indicators and rank and compare regions and enterprises considering a whole set of features.
In the table 2.4 main strength and weaknesses of composite indicators are presented.

Table 2.4 Pros and cons of composite indicators

Pro	**Cons**	**Methods to mitigate**
Summarise complex and multi-dimensional issues	May send misleading policy messages	Sensitivity analysis
Simplify the ranking procedure	Simple big picture may lead to simplistic policy conclusion	Composite indicator should be used in connection with sub-indicators
Attract public interest	Value judgments cannot be avoided	Judgment should be transparent and based on statistical methods
Reduce the size of indicators, include more information within existing size limit	Increase the quantity of data for composite indicator	

Source: adopted from Saisana & Tarantola 2002
Gómez-limón & Sanchez-fernandez (2010) point out that the most of limitation of composite indicators could be controlled by improving accuracy and transparency in selection of indicators, but the problem of “subjective” character is still under debate. For example Morse et al. (2001) conclude that “qualitative integration” including value judgnments and subjectivity is inevitable in such concept as sustainability.
Accordingly, indicator frameworks have been developed to create a systematic basis for SD assessment and to assist policymakers avoiding biased indicator selection (Gudmundsson et al., 2016).
As was already mentioned theoretical framework should be the basis for selection of indicators and their weights. The composite indicator should carry the information about core elements and should be based on the paradigm concerning the behaviour analysed (COIN, 2019).
It could be seen that composite indexing is a controversial topic, which has clear advantages and disadvantages. Nevertheless beside the discussion about strengths and limitations of aggregated indicators the literature shows plenty examples of techniques available to build sustainability indices (Gómez-limón and Sanchez-fernandez, 2010).
Following steps should be taken on the way to composite index (Gómez-limón and Sanchez-fernandez, 2010; Nardo et al., 2008; Singh et al., 2009):

1. Developing theoretical framework
2. Indicator selection
3. Multivariate analysis
4. Imputation of missing data
5. Normalization of indicators

6. Indicators weighting and aggregation
7. Robustness and sensitivity
8. Links to other variables
9. Visualization
10. Back to the real data.

These ten steps are the "ideal sequence" offered by OECD handbook on composite indicators construction (Nardo et al., 2008). It goes from development of theoretical framework to the analysis of underlying data once the indicator is built. Each step has a great importance itself, but the coherence of the whole process is equally important (Nardo et al., 2008).

Composite indicators could be composed with parametric and non-parametric methods (Bo and Woo, 2008). Non-parametric methods are directly assigning weights to the indicators on the base of researcher's beliefs about relative importance of the indicators. The parametric methods are using structure of variance and they determine weights by the covariation between them on each dimension of the structure. Non-parametric methods are highly subjective and even a small change in the relative weights are leading to alterations in composite index (Bo and Woo, 2008). Parametric methods are statistically sound because there are determined by sample indicators themselves.

Next question is the orientation of the properties. For example, growing birth and death rates are dragging demographic development in opposite directions. Those properties are not similarly oriented, for the performance of partial analysis the data must be transformed, so that it has common monotonicity with the aim (Brüggemann and Patil, 2011).

On the one hand: without weights, a ranking would mean to fight losing battles because of too much incomparability. However, on the other hand: any incomparability implies a compensation: good values in one indicator may average out bad values of other indicators and vice versa in getting a composite indicator (Brüggemann and Patil, 2011).

From a statistical point of view, the construction of composite indicators can help identify priority indicators for development and weaknesses in existing data. The current trend towards constructing composite indicators of country performance in a range of policy fields may provide an impetus to improving data collection, identifying new data sources and enhancing the international comparability of statistics (Unece et al., 2013).

There are many examples of the use of composite indicators, as synthetic indices could be very useful for summarizing complex and multi-dimensional data into a single and intuitive value to communicate to policymakers and the general public (Campagnolo et al., 2018). Such examples are HDI – Human development index (United Nations development programme, 2005), the Well-being index (Prescott-Allen, 2001), the FEEM SI sustainability index (Carraro et al., 2013) and the SDG index (Campagnolo et al., 2018).

Composite indicators lend themselves to a weak sustainability paradigm, which assumes a certain degree of substitutability and compensability (Stiglitz et al., 2009). Such substitutions have been criticized for: the uncertainty that substitution is truly possible; the irreversibility of some form of environmental damage and the necessity to maintain most natural resources above critical levels to support life and maintain environmental resilience (Ekins et al., 2003; Sardain et al., 2016; Stiglitz et al., 2009). One of the opportunities of minimising the loss of information and limiting the shortcoming of the composite indicators is to use an approach known a dashboard of indicators. But the dashboard is keeping the indicators in non-aggregated way and it can appear to deliver a lot of information at once, which could complicate the interpretation (Mazziotta and Pareto, 2013; Sardain et al., 2016; Stiglitz et al., 2009).

Commission on Sustainable development adopted three editions of Sustainable Development Indicators (SDIs) Guidelines and methodologies, which guides countries to develop their own indicator sets (United Nations Commission on Sustainable Development (UNCSD), 2007, 2001, 1996). The last edition in 2007 emphasized the multi-dimensional nature of sustainable development and reflected the importance of integrating its pillars (United Nations Commission on Sustainable Development (UNCSD), 2007). The SDIs framework included 96 indicators

belonging to 14 themes (United Nations Commission on Sustainable Development (UNCSD), 2007).
With the respect to Millennium Development Goals indicators (MDGIs) UN have offered 48 indicators which were grouped on eight goals with 18 targets in 2001, but in 2007 the MDGIs were updated to four targets and 10 indicators (Dang et al., 2018). In 2015 the SDGIs were designed to substitute the MDGIS (United Nations Statistical Commission (UNSC), 2017).
The SDIs are used to track progress towards national sustainable development and to track, monitor, and assess a national sustainable development strategy, while MDGIs and SDGIs were developed for the global monitoring of progress toward meeting globally established goals (Dang et al., 2018; United Nations Commission on Sustainable Development (UNCSD), 2007). All of them are designed to make policies toward sustainable development, but the SDIs cover a broader range of issues than SDGIs, which are specific to the seventeen SDGs (Dang et al., 2018).
One of the limitations of the composite indicator measurement is the fact that this approach is data-driven, and data are essential to the validity of the analysis. Generally, the economic data are largely complete data on environment, equality, social matter suffers from incompleteness and bad quality (Spaiser et al., 2017).
Spaiser et al. (2017) in their research have tried to quantify the inconsistency between social-economic development and ecological sustainability, and the research has shown that economic growth fulfils socio-economic goals while simultaneously hindering environmental goals. But the model has identified factors which can contribute to socio-economic development on the one hand and ecological sustainability on the other, without triggering the conflict between incompatible SDGs (Spaiser et al., 2017).
The process of composite indicator creation is full of subjective decisions and the information loss is unavoidable, but there is a consensus in the scientific literature that there is a need to measure the progress towards sustainability and composite indicator is a suitable tool for reaching this aim (Diaz-Sarachaga et al., 2018; Hudrliková, 2013; Klein, 2020; Talukder et al., 2017).

2.5 Education for Sustainability

The importance of sustainability issues was first stated in UN World Commission of Environment and Development (WCED) Brundtland Report in 1987 and it was followed by a "Agenda 21" at the Rio Summit 1992 where the importance of education for sustainability was underlined (Kuzich et al., 2015). Already in the beginning of 2000s it became clear that without a strategy for sustainable development the conditions are more likely to worsen than improve (de Haan, 2006). Especially was underline the importance of transformation of the ecological education into education for sustainable development (Jickling and Wals, 2008).
The importance of promoting education for sustainable development and integrating sustainable development was also emphasized in paragraph 233 of the "Future we want", the Outcome of the United Nation Conference on Sustainable Development, Rio +20, in 2012 (United Nations, 2012).
In 2017 UNESCO presented a report where the importance of the education for sustainable development for achievement of SDG was underlined (UNESCO, 2017). In the report it was also stressed, that the approach of Education for Sustainable Development empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society for present and future generations, and therefore education is playing a crucial role in reaching sustainability (UNESCO, 2017).
The debate on how the sustainability should be reached is still ongoing, but in general it is clear that it could not be accomplished without a far-reaching modification in the human way of life, without a major shift in our dominant patterns of production and consumption (Kopfmüller et al., 2001). And to change the way of people´s life there is a need for mental shift which could be only achieved through learning (de Haan, 2006). Education alone could not move the citizens and governments to create a more sustainable future but it is still essential (UNESCO, 2005).

UNESCO (2005) is stating that it is important to reorient education to address sustainability, to improve public awareness and to provide training to different sectors of society. That is why it is important to re-educate teachers who have potential to bring changes within educational systems that will shape the knowledge and skills of future generations and nations should include teacher education institution in their national sustainability plans (UNESCO, 2005).
De Haan (2006) is underlining following important feature of the education for sustainability:

- Interdisciplinarity, as the problems of ecology and sustainability can no longer be approaches form any single specialized field of science
- Participation, the learning should also be participative to train communication skills, as the sustainability can only be reached when people work together
- Innovative structures, as the sustainability problems are challenging people to find new solutions to existing problems

De Haan (2006) is also stating that sustainability education is not only about transferring knowledge it is about shaping competence, which means a specific capacity to act and solve problems. People who possess such competences can help, through their active participation in society, to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development (de Haan, 2006). The most important competences are:

- competence in foresighted thinking, sustainability education should provide the capacity to deal with uncertainty and future prognoses, and competence to think beyond the present
- competence in cosmopolitan perception, transcultural understanding, and cooperation – capacity to identify and localize phenomena in the context of their global relations and effects
- competence in interdisciplinary work, as sustainability is including different disciplines – the ability to collaborate many scientific fields different cultural traditions and aesthetic, cognitive and other approaches is crucial
- competence in planning and implementation – an ability to assess resources necessary for an action, the capacity to create cooperative networks and to calculate side-effects
- capacity for empathy, compassion, and solidarity, as the sustainability is promoting justice the sustainability education is supposed to aim to develop individual and collective competence in acting and communicating in the spirit of international solidarity
- competence in self-motivation and in motivating others, as was already mentioned to reach sustainability there is a need of change of the usual lifestyle and this change requires a great deal of motivation to change oneself and to encourage others to change as well.

Education for sustainability promises a different kind of education: one that is premised on a systemic, ecological worldview that encourages interdisciplinary, holistic and transformative teaching and learning (UNESCO, 2005).
According to Agenda 21 in the education for sustainability there are four major thrusts (Ercoskun, 2011):

- Improvement of basic education, according to the McKeown et al. (2002) basic education is key to a nation´s ability to develop and achieve sustainability targets
- Reorientation of existing education to address sustainable development, reoriented education is expected to transfer knowledge, skills, perspectives, and values, that will guide and motivate people to pursue sustainable livelihoods, to participate in democratic society, and to live in a sustainable manner; reorientation is important on basic as well as on secondary levels
- Development of public understanding awareness – creation of informed voting citizenry, which lends support to enlightened policies and government initiatives, can help governments enact sustainable measures

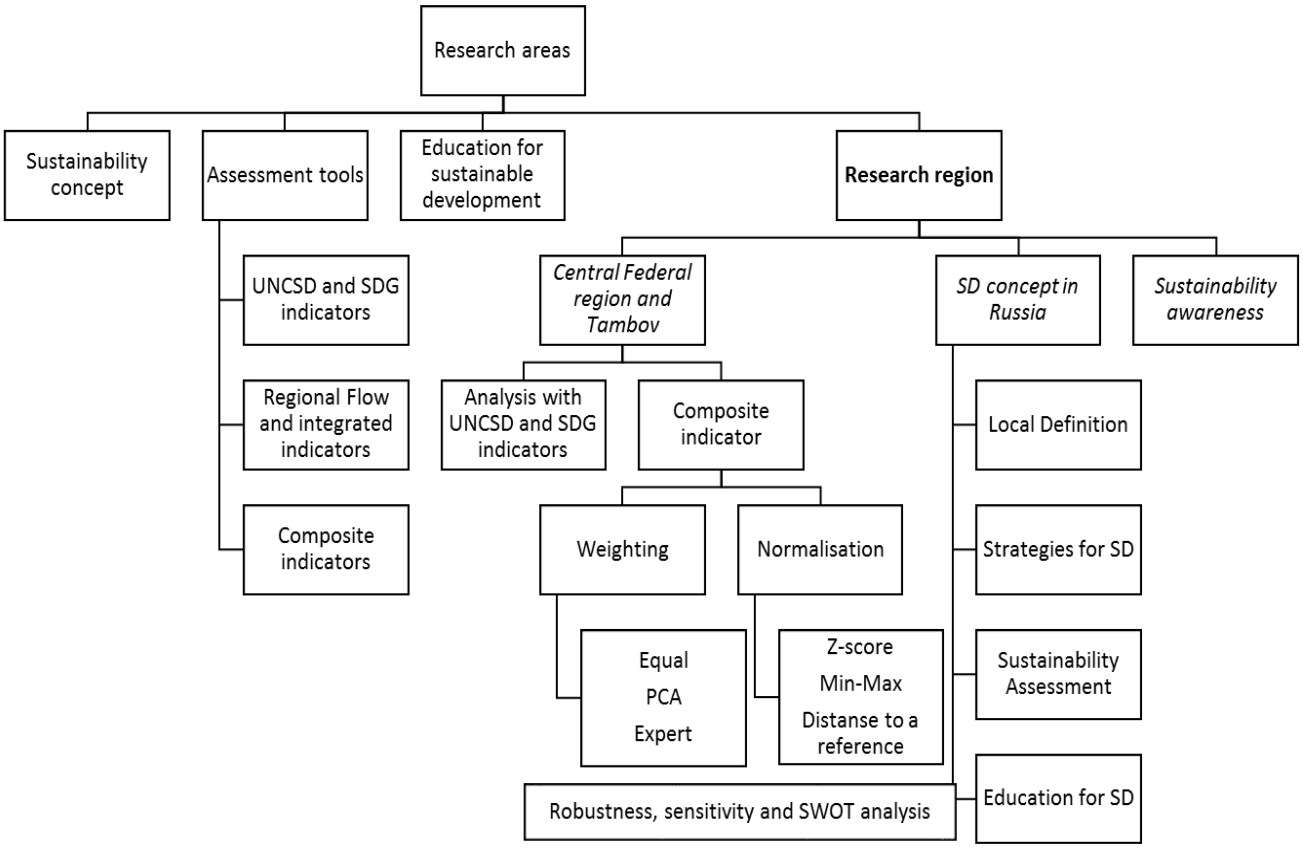
- Training – it is informing people of accepted practices and procedures, that gives them skills to perform specific tasks in a more sustainable manner.

In teaching sustainability it is important that teachers enrich their learners´ knowledge about environment and abilities to understand, criticise and participate rationally in the discourse or controversial, value-laden issues of sustainability (Anyolo et al., 2018). However, teachers often have difficulties in terms of understanding the complexity of sustainable development issues, and they are only aware of local issues and are seemed to underestimate the global ones (Spiropoulou et al., 2007).

2.6 Research region

In the following chapter the research region is presented, the administrative structure of the Russian Federation, and main characteristics of the region.

Fig. 2.3 Linkage of the chapter to the overall structure of the thesis.



Source: own illustration

Tambov region is a federal subject of the Russian Federation, and it was chosen as a research region for this study.

Federal subject is a constituent entity of Russia, its top-level political divisions according to Constitution of the Russian Federation, which was adopted in 1993 (Constitution of Russian Federation 1993, 1993). Since March, 2014 Russia consists of 85 subject, although two recently added subjects are internationally accepted as Ukraine (General Assembly of United Nation, 2014; President of Russian Federation, 2014).

2.6.1 Administrative structure and Central federal district of the Russian Federation

In 1992 Russian regions signed the Federation Treaty establishing and regulating the current inner composition of Russian Federation. The Federation Treaty states the division of authorities and

powers among Russian government bodies and government bodies of constituent entities (Representatives of Russian Regions, 1992).

Table 2.5 Characteristics of subjects of federation.

No.	English official translation of the constitution	English unofficial translation of the constitution	Description
87	Constituent entity of the Russian Federation	Subject of Russian Federation	
46	Oblast	Region	The most common subject with a governor and locally elected legislature. Commonly named after their administrative centre.
22	Republic	Republic	Nominally autonomous, each has its own constitution and legislature; is represented by the federal government in international affairs; is meant to be home to a specific ethnic minority.
9	Kraj	Territory	Essentially the same as oblasts. The title "territory" is historic, originally given because they were once considered frontier regions.
4	Autonomous okrug	Autonomous area	With substantial or predominant ethnic minority
3	City of federal significance	City of federal importance	Major cities that function as separate regions.
1	Autonomous oblast	Autonomous region	The only autonomous oblast is the Jewish Autonomous Oblast

Source: Constitution of Russian Federation, 2020

According to the Russian Constitution there are such types of federation subjects as: republics, kraj, oblast, cities of federal importance, an autonomous oblast and okrugs, all of which are equal subject of the Russian Federation with no right for separation (Constitution of Russian Federation, 2020). Every subject of the Russian Federation has its own president/governor/head, regional parliament, and regional constitutional court. Federal subjects shall have their own constitution. All federal subjects have equal rights for representation in the Federation council and the upper house of the Federal assembly. Nevertheless, they differ in the degree of autonomy (asymmetric federalism) (Constitution of Russian Federation, 2020).

Federal subjects make up together nine federal districts. In the table 2.6 number of federal subjects that comprise the federal district and the administrative centres are presented.

The main purpose of creation of federal districts was the coordination activities and the formation of common economic policy. Federal districts are playing following roles (Mitrofanova, 2014):

1. They serve as a unifying element in a federal state, thus protecting it from attempts of subjects to become more independent entities
2. Creation of federative districts gave an opportunity to unify the system of territorial management, it has normalised the regulatory and legal framework.

Table 2.6 Characteristics of federal subjects

	Federal subjects	Administrative centre
Central federal district	18	Moscow
Southern federal district	6	Rostov-on-Don
North-western federal district	11	Saint-Petersburg
Far Eastern federal district	9	Khabarovsk
Siberian federal district	12	Novosibirsk
Ural federal district	6	Yekaterinburg
Volga federal district	14	Nizhny Novgorod
North Caucasian federal district	7	Pyatigorsk
Crimean federal district	2	Simferopol

Source: Constitution of Russian Federation, 2020

In the figure 2.4 the map of federal districts is presented; the Crimean federal district is not presented in the map. With red colour the central federal district is marked. It is in the European part of Russian Federation, and it consists of 18 federal subjects, 17 of them are oblasts and one is the city of federal significance (Moscow). Its administrative centre is in Moscow.

Central federal region is the most populated region in Russia – 27 % of citizens are living here (EMISS, 2021). Population density is equal to 60,37 people/km^2, when average population density is equal to 8,54 (EMISS, 2021). Around 82,68 % of population is living in urban areas and less than 18% in rural, but there is a clear trend of growing urban population (EMISS, 2021). Almost half of population of the federal district is living in Moscow (32,1 %) and Moscow region (19,6%) (EMISS, 2021).

Fig. 2.4 Federal districts of Russian Federation

Source: https://en.wikipedia.org/wiki/File:Central_in_Russia.svg#filehistory

Central federal district is located on East European plain, there are Valdai, Smolensko-Moskovskaya and Central Russian Upland; Meschera and Oksko-Dosnkaya lowlands. The highest point is 347 meter (Valdai) (Glushkova et al., 2016).

It has boarders with Belarus in the west, with Ukraine in the southwest. Also, it has inner boarders with Southern, Volga and North-western federal districts of Russia (Glushkova et al., 2016).
There are several important rivers (tributaries in the brackets): Volga (Oka), Don (Voronezh), Dnepr (Desna, Seim), Zapadnaya Dvina. There is no direct way to the sea.
There are 4 different terrestrial ecosystems (From North to the South): mixed coniferous forest, temperate deciduous forest, forest steppe, steppe. Climate is mild-continental, with average temperature of January from -7 to -14°C, July – from +16 to +22°C (Glushkova et al., 2016).
The central federal district is reach with natural resources. The Kursk Magnetic Anomaly is a territory rich in iron ores and located within the Kursk, Belgorod and Voronezh regions, it is recognised as the largest magnetic anomaly on earth 60% of Russian reserves of iron ore is located there (Blackstock et al., 2006). Also, the district has reserves of phosphates (25%), bauxites (15%), brown coal - production of 1.5 million tons, cement raw materials (25%), granite (mining by the open method, 2 quarries in the Bogucharsky and Pavlovsky districts of the Voronezh region), ochre, peat. The region has some forest resources, but the forest cover is almost twice as lower as in other regions (20%) and forests have mostly recreational, water protective and regulative value (Dmitrichenko, 2016).
Central federal region is one of the most important agricultural regions of the Russian Federation. In 2015 43,1% of the gross harvest of flax fibre, 47.7% of the harvest of sugar beet, 33% of the total harvest of potatoes, 17.2% of the total grain harvest, 15.2% of the harvest of sunflower seeds, 23.3% of the harvest of vegetables, 28.4% of production milk, 21% of meat production (EMISS, 2021).

2.6.2 Tambov region

One of the aims of this research is to develop a methodology for sustainability assessment, it is important that this methodology will be applicable not only to the one region presented in the research, but that the methodology will be transferable to other regions. That is why Tambov region was chosen for this research, because it represents an average region from central federal district, and it is expected that the methodologies tested in this region will suit the most of Russian regions. Tambov region covers an area of 34500 km^2 with population of 995,76 thousand people and 42 % of them are living in rural areas. 2,5 % of population of central federal district is living in Tambov region (EMISS, 2021).
The region is in a forest-steppe zone with a moderately warm climate. The main wealth of the region, its huge natural potential, is its exceptionally fertile black earth soil. Chernozems here are less powerful than in Ukraine, but richer in humus (Ministry of agriculture Tambov region, 2019). The region has favourable climate conditions. The climate is temperate continental with January´s average temperature of -10,5°C and July +19,4°C (Regional'nyj informacionno-konsul'tacionnyj centr agropromyshlennogo kompleksa, 2019).
The growing season is 189 days, annual precipitation ranges from 322 to 807 mm. The relief of the region is a lowland plain with a prevailing height of about 150 m above sea level. In the region, water resources are represented by surface and groundwater bodies. The rivers of the region belong to the Volga and Don basins. There are 1,400 rivers and streams in total of which 1390 are less than 100 km long, 900 ponds and reservoirs, 300 small lakes. The total length of all the rivers of the Tambov region is 9111 km. The largest rivers of the region are Tsna, Vorona, Voronezh (Ministry of agriculture Tambov region, 2019; Regional'nyj informacionno-konsul'tacionnyj centr agropromyshlennogo kompleksa, 2019). The artificial water bodies, which partially regulate the flow of Tsna, include 10 hydroelectric complexes. Zninsky lock system, which serves to supply industrial enterprises of Tambov and Morshansk, irrigation of land and the creation of favourable water air regime of floodplain agricultural land (Regional'nyj informacionno-konsul'tacionnyj centr agropromyshlennogo kompleksa, 2019).
The geographical position of the region is favourable for the development of economic activity. The region occupies the north-east of the Central Black Earth economic region. Tambov region is

intersected with important railways and highways, and it is well connected with Central Russia, the Volga region, the South and the West of the country humus (Ministry of agriculture Tambov region, 2019).
The land fund of the region includes more than 3.4 million hectares, 78.9% of it is agricultural land (87% of chernozem). Black soil and flat terrain allow to grow grain (2% of Russian production) , sugar beets (9,6 % of Russian production), corn (4,3% of Russian production), sunflower (5,5% of Russian production), barley (3,9% of Russian production), pea (5,1% of Russian production), potato (3,3% of Russian production), fruits and meat and dairy products (EMISS, 2021). Forest land makes up 0.3 million hectares (8.8%) of the regional land fund (Ministry of agriculture Tambov region, 2019).

2.7 Sustainable development in Russian Federation

Russia was a participant at the 1992 Earth Summit and a signatory to the conference´s main policy, including Agenda 21 and the Rio Convention (Oldfield and Shaw, 2002). In 1996 a decree "About a concept of transition to sustainable development in Russian Federation" was approved by the president of Russian Federation (Ukaz, 1996). According to this decree Russian government was supposed to approve a concept of sustainable development and to consider this concept during development of forecasts, socio-economic programs, preparation of regulatory legal acts and other decisions. Furthermore, Russia has participated in international activities designed to monitor the impact and overall effectiveness of Agenda 21. It is clear that at least at the level of rhetoric, sustainability has entered the Russian policy agenda (Oldfield and Shaw, 2002). While Russian government officially stated the commitment to sustainable development, the crucial question is how the concept of sustainability is understood and interpreted. There is a danger that commitment to sustainable development in rhetoric is not always a commitment to the similar interpretation of sustainable development (Oldfield and Shaw, 2002).

2.7.1 Local definition

The first problem in defining sustainability starts with the translation of the word "sustainable". The official Russian term "*ustoichivoe razvitie*" literally means "stable" or "steady" development and some scientists are arguing that the Russian translation is more suitable than the word sustainability (Danilov-Danilyan, 2003). In the concept of sustainable development approved in 1996 sustainable development was defined as "a stable socio-economic development that does not destroy its natural base". This definition is overlapping with Western understanding of the sustainability concept, but there are still some points which are different. For example, the decree form 1996 asserts: "The idea of Sustainable Development is extremely consonant with the customs, spirit and mentality of Russia" (Ukaz, 1996). Oldfield et al. (2002) states that linking sustainable development aspirations with "spiritual" and cultural need is rarely found in official Western rhetoric. The final section of 1996 decree also claims that "advancement of humanity to sustainable development would ultimately lead to the emergence of the sphere of wisdom (the noosphere) foreseen by V. I. Vernadsky, when the spiritual values and understanding of humankind, existing in harmony with the environment, will become the principal criterion of national and individual wealth" (Ukaz, 1996). Oldfield et al. (2002) comes to conclusion that there should be differences in definition of sustainable development, it is not possible to create undifferentiated global vision of human development and the definition of development should consider cultural and scientific heritage.
In Russian condition cultural and scientific heritage includes some concepts which could be seen as predecessor of sustainability (Kasimov et al., 2004). One of them is the Russian concept of environmental management by Armand. In his book "For us and our grandchildren" he sets out in detail the scientific approach to the use of natural resources as priority and eternal values of the human community. This book was a manifestation against wasting and neglecting of the nature

values, Armand described the environmental protection as a part of people moral duty towards other people and future generations (Armand, 1966).
While Russian government was showing conformation with Western principles of sustainability there were still some controversial decisions taken. For example, the decade after USSR collapse was very difficult for Russia and there were many problems connected to the transition to market economy and this situation required political action, and Russian government have reacted with completely unsustainable decision – using oil and gas export as a backbone of Russia´s economic recovery (Henry and Douhovnikoff, 2008).
To implement sustainability programmes and policies not only political decisions should be taken, but also the conditions should be created necessary for the full participation of citizens within the development and implementation of such policies (Farmer and Farmer, 2001). It is also complicated in Russian conditions, because as a result of the transition period´s influence on the citizen´s attitudes towards the environment, the importance of environment protection has become second to economic stability and falling living standards (Farmer and Farmer, 2001; Henry, 2010; Huffman et al., 2010).
From one side researchers are admitting that the citizen´s awareness of the ecology importance is not so strong, but when the sustainable development is discussed in scientific circles or on governmental level the ecology becomes the centre of discussion and all other aspects are briefly mentioned or even neglected (Danilov-Danilyan, 2003; Kasimov et al., 2004).
For example, in the concept of the sustainable development created by Russian ministry of agriculture sustainable rural development is defined as "stable" development of rural society providing (Ministry of agriculture, 2010):

1. Performance of production functions (production of food, agricultural products and other non-agricultural commodities and services, as well as public goods, recreational services, safety of rural way of living and rural culture, social control of the territory and safety of historically used landscapes)
2. Reproduction of population increase of level and quality of life of rural citizens
3. Support of ecological equilibrium in the biosphere.

The definition of sustainable rural development is trying to include three dimensions of sustainability, but the main idea of the sustainability is slightly touched on the surface. The complex ecological, economic, and social dimensions are substitutes with production, demographic, and ecological equilibrium. The authors of definition are trying to simplify the initial concept of sustainability, but on the next stage of decision selection for the sustainability following goals are set (Ministry of agriculture, 2010):

- increase the level of comfort living conditions
- increasing the availability of improved housing for the rural population
- increase the prestige of work in rural areas and the formation in the society of a positive attitude towards the rural way of life
- improving the demographic situation
- rural development of local government and civil society institutions.

It is often underlined that the sustainability term in Russia is used in context of sustainable economic growth and strategic documents on sustainable development lack a balance between economic, social and environmental components (Bobylev and Solovyeva, 2017; Rukin, 2008).

2.7.2 Strategies and policies for sustainable development in Russia

As was already mentioned in 1996 the first decree on sustainable development was adopted and the sustainability principles were mostly integrated into environmental legislation. In year 2002 new federal law "About environmental protection" entered into force, but it had reference character and required adoption of more detailed regulations.

2006 the adoption of the new Forest and Water Code of the Russian Federation, which treats forest and water bodies mainly as resources but does not establish the necessary mechanisms for their protection as environmental components (Hmeleva, 2014; The World Bank, 2009).
In 2006 the changes in Town planning code of the Russian Federation entailed the abolition of the mandatory state environmental impact assessment for most of the objects, including especially dangerous ones and replacing it with a unified state expert review. Also, these changes entailed a decrease in the possibility for the public to participate in making environmentally significant decisions. In political discourse the need for more applicable legislation was widely discussed and the need for environment protection was secured by a decree of the President of the Russian Federation in 2008 (Ukaz, 2008).
The changes in legislation had entered active phase only after State Council of Russian Federation issued lists of instructions in 2010 and 2011. This instructions were devoted to the improvement of the procedure of environmental impact assessment and the inclusion of strategic environmental assessment in the decision-making system; the creation and development of economic mechanisms for environmental protection, including the possible restoration of environmental funds; protection of the seas from oil pollution; development of legislative support for the functioning and financing of specially protected natural territories; the creation of legal mechanisms for the elimination of accumulated environmental damage, as well as the adoption of the Fundamentals of the State Environmental Policy until 2030 (The World Bank, 2009).
30 April 2012 president of the Russian Federation has approved the Basics of the state policy in the field of environmental development of Russia for the period up to 2030. Considering the experience of the Ecological decree 2002, when the decree did not result in actions directed towards sustainable development, this time the Basics stipulated that for their effective implementation it is necessary to determine target indicators of environmental impact, as well as the characteristics of responsibility for environmental use (Hmeleva, 2014).
Another problem is that the main principles of sustainable development are reflected in constitution of Russian Federation and ecological legislation, but there is no consistent focus on sustainable development in the legislative system (Hmeleva, 2014).
The statistic can be also tricky, for example on a very large scale the forest use appears sustainable, but on a local or even regional basis, the numbers may conceal serious depletion of forest resources (Henry and Douhovnikoff, 2008).
In 2018 a plan for national development until 2024 was signed by the president of Russian Federation (President of Russian Federation, 2018). It contained 9 aims, which were corrected into 5 blocks for national development until 2030 in 2020 by presidential decree (President of Russian Federation, 2020):

1. Preservation of the population, health, and well-being of people
2. Creating of opportunities for self-realization and development of talents
3. Comfortable and safe living environment
4. Decent, efficient work and successful entrepreneurship
5. Digital transformation

The aim have 24 indicators, some of them could be quantified, some of them are formulated as a statement, for example one of the indicators for the 1st aim is “ensuring sustainable growth of the population of Russia”, but there is no definition what exactly is meant by the sustainable growth (President of Russian Federation, 2020). Nevertheless, the fact that not all the aims are provided with quantifiable indicators, and for some indicators which are measurable no reliable statistical data is collected, still the decree of the Russian President is a starting point for the revision of the national projects aimed to reach SDG.

2.7.3 Sustainability assessment in Russian Federation

The sustainability concept is integrated into policymaking in Russia, and it is also reflected in the statistical data which is collected by different ministries and administrations. After 46th session of

UN statistical commission in March 2015 an Inter-agency and expert Group on Sustainable development goal indicators was formatted with aim of development of indicators system to control the reaching of the global sustainability goals (United Nations, 2015b).
It is important to mention that Russia has some experience in sustainability assessment, different indicators of sustainability were introduced by the regional governments of Tomsk, Samara, Kostroma, and Kemerovo regions. In these regions the assessment was conducted with the methodology of adjusted savings and this assessment confirmed that inclusion of the social and ecological costs is significantly reduces the overall assessment of the economic growth (Bedrickij, 2012). For example, in Kemerovo if only economic indicators are included into the assessment a conclusion could be made that the region is economically growing. But adjusted savings indicated average -10% decrease due to ecological degradation, population decrease, and low life expectancy (Bedrickij, 2012).
There are also several organisations which are publishing sustainability ratings of the Russian regions, for example rating agency "Interfax" and Green Patrol (Green patrol, 2018; Interfax, 2019).
Russia is a member of UN statistical commission and in 2017 the sustainable goal indicators were added to the federal plan of statistics collection in Russia. Many of the indicators are collected only on national level and collection started in 2017 and there is not enough data for comparison yet (Analytical center of government of Russian Federation, 2016).
Many of the indicators are repeating the UNCSD indicators, but there is no assessment system, there are several governmental bodies which are collecting and reporting statistical data and they do not communicate with each other and there is no governmental structure, which could perform an integrated assessment of sustainability(Analytical center of government of Russian Federation, 2016). Another problem is that, national statistics are not very sensitive to changes and often operate on data that have proven their effectiveness in the past only (Nekhoda et al., 2018).
There are 241 indicators, which are recommended for the sustainability assessment by UN, only for 63 indicator there is available statistical data on national level in Russia, on regional level only 3 indicators are available (EMISS, 2019; United Nations, 2015a).
There are some examples of the use of composite indicator for the well-being assessment in Russia (Kislitsyna, 2017; Kozlova et al., 2015; Nekhoda et al., 2018; Pystogova, 2015). For example, in the research of Kozlova et al. (2015) the integral assessment of the quality of life is calculated as a weighted average of both objective and subjective indicators, the objective indicators are based on statistical data and the subjective indicators on the base of satisfaction index based on surveys results (Kozlova et al., 2015).
Nevertheless, there are several problems in the indicator-based sustainability assessment in Russia (Panteleeva, 2010):

- Absence of the national standards and normative base for regional indicator system
- Lack of reliable statistical data, incompleteness, and irregularity of measurements of the available data
- Lack of expertise for the choice of indicators on the local level.

The last problem is connected to another issue to the lack of education in the sphere of sustainability and the limited opportunities for involvement of the citizens into sustainability problems identification and problem-solving. Since Johannesburg declaration on sustainable development (2002) an aim of integration of sustainable development questions into educational system was set (Bedrickij, 2012). Unfortunately, this integration was limited to the addition of environmental disciplines to the school and university curricula (Bedrickij, 2012).
There are some attempts to involve citizens and non-governmental organisations into participation into environmental problem-solving. One of the areas where such participation is used is the research conducted by NGO devoted to the development of the indicator system and its application on the regional level (Bedrickij, 2012).

For example, sustainability institute of the civic chamber of Russian Federation was established in 2009 and one of its aims is to develop the basics of national environmental policy and sustainable development policy. This institute is conducting work on indicator development, which are reflecting costs of economic growth for people´s health and environment (Global network of national council for sustainable development, 2010).
There are also some attempts of monitoring of the progress towards reaching the SDGs, in 2020 the first voluntary national review (VNR) was presented by the analytical centre of government of Russian Federation (Radchenko, 2020). Simultaneously with the work on the official VNR a group of experts was preparing an alternative review of the SDGs in Russia – the so-called Voluntary civil review (Radchenko, 2020). These reviews had different aims, the first one aimed at monitoring the progress of development towards SDGs, the second one aimed at collection of the recommendations from the representatives of civil society (Radchenko and Rakhimova, 2020). Voluntary civil reviews have been initiated also with an aim of complementing the VNR, as the VNRs tend to highlight positive trends and neglect problems (Radchenko and Rakhimova, 2020; Titov, 2021).
There were some critics of the statement, that the Voluntary civil review was created with active participation of the civil society, as some of the organisation which wanted to participate in the creation of the review were not informed, remote participation was not possible and the participation was limited to the state organisations (Radchenko and Rakhimova, 2020; Titov, 2021).
There were critics of the correspondence of the national development project and the SDGs, the authors of the VNR state that 107 of 169 SDG targets are covered, on the contrary the authors of civil review are admitting that only 57 of targets could be considered as covered (Analytical center of government of Russian Federation, 2020; Titov, 2021).
Also analytical centre of government of Russian Federation have stated that the process of preparing of VNR have created a base for monitoring of SDGs, but there is a lack of a coherent long-term strategy of action (Radchenko, 2020; Titov, 2021).
To sum the topic of sustainability development in Russia up, the table 2.7 presents a summary of possible strengths and problems.

Table 2.7 Possible strengths and problems of the sustainability issues in Russia

Advantages	**Problems**
The topic of sustainability is present in pollical and scientific discourse	Presence in official documents does not always lead to practical issues
There are development concepts and strategies which state sustainability as one of their main aims	Many concepts state sustainability as their aim, but neglect the complexity of the concept or disregard one or more aspects of sustainability
There are several legislative acts which regulated the necessity for sustainability	The legislative base is underdeveloped, sketchy and does not cover all aspects of sustainable development
There are governmental structures which are responsible for assessment, monitoring, and analysis of sustainability	The governmental structures are uncoordinated and lack communication
Russia has adopted Paris Agreement as well as SDGs	Adoption of agreements does not always lead to the effective actions, or integration into the strategies/concepts

Source: own elaboration

These strengths and weaknesses have a common pattern, the strengths are usually reflecting the official position of the Russian government, which is showing active participation in the sustainability problems, they are elaborating new strategies, concepts, and legal documents, they are adopting agreements, creating special departments to deal with the sustainability; and at a first glance Russia is successfully integrating the sustainability into political activities of the country.
But there are some critics of the governmental actions, for example Coalition for Sustainable Development of the Country (KURS) is stating that SDGs are not integrated into strategic planning, into executive power on the national and regional levels (Koaliciej za ustojchivoe razvitie strany (KURS), 2020). KURS (2020) is also stating that Russian government is declaring active participation of the civic society, but the state imposes an excessive control over NGOs, it creates obstacles for the activities of independent human rights and environmental organizations, whose expert is necessary to achieve the SDGs. In addition, according to KURS (2020) the spread of corruption makes it difficult to achieve the SDGs, another problem is the amendments to the constitution which were adopted in 2020. One of the amendments provides a possibility of not executing decision of the international agreements, when it contradicts the Constitution of Russian Federations (Constitution of Russian Federation, 2020).
According to the Report on Human Development in the Russian Federation for 2015 the level of welfare has increased in the period 1990-2015, the share of people belonging to the so-called middle class tripled, the extreme poverty has reduced, the health and educational sphere has expanded (Salmina, 2014). At the same time the inequalities between different regions have grown and in the socio-economic researches it is admitted an excessive level of inequality between Russian regions (Salmina, 2014). In this regard, the analysis of sustainability indicators seems to be an urgent task, which could allow timely identification of problems and development strategies (Kirillov et al., 2017).
The topic of the sustainability assessment is presented in Russian scientific as well as in political discourse, but it could be seen that there is still room for development and there is a need for a set of simple indicators at the regional level, that could be used by local authorities, reflecting local interests and satisfying needs of different stakeholders (Mardenskaya, 2017; Radchenko and Rakhimova, 2020; Titov, 2021).

2.8 Sustainability education in Russia

Education system in Russia has experienced several shifts in last decades (Pavlova, 2009). In Soviet times all the educational reforms were formulated through “top down” orders, and only in the 1990th the law on education shared responsibility for curriculum development across three levels: federal, regional and local (Pavlova, 2009).
The main instrument in this “top down” approach was the federal state educational standards (FGOS). These standards are a set of requirements that are mandatory in the implementation of basic educational programs of primary general, basic general, secondary (complete) general, primary vocational, secondary vocational and higher vocational education by educational institutions that have state accreditation (The Ministry of Education of the Russian Federation, 2015).
The federal (compulsory) component of the curriculum defined by the standards (FGOS) was viewed as a minimum level of education guaranteed by the state in order to maintain the quality of education (The Ministry of Education of the Russian Federation, 1996).
The first steps into the direction of decentralization of education were done, but due to the lack of funding an aim of transition to a balanced development of education in the new political and socio-economic condition was not fully achieved (Pavlova, 2009).
In 2001 a new attempt of education modernisation was taken and four priorities for state policy were identified among them were a state guarantee of education accessibility, increasing the quality of general education, increasing the quality of vocational education and development of effective financial relationships (The Ministry of Education of the Russian Federation National Fund for

Personal Training, 2001). This modernisation had an aim of changing a curriculum content in order to reach a compromise between traditional cultural values and educational traditions and the new demands of international economic development (Pavlova, 2009).
In Soviet times education had an aim to provide systematic scientific knowledge and skills, in the beginning of 2000th education became a process of pedagogically organized socialization aimed at the interests of person and society (Lebedev and Neupokojeva, 2001). Lebedev and Neupokojeva (2001) see socialization as the main aim of education, person with a certain education is supposed to be the subject of activity and it gives a possibility to carry out different social roles. Early an aim of education was to give certain knowledge and skills, in 2000th the emphasis shifted to development of "cultural" person who would potentially be able to solve problems in different fields.
The Ministry of education of the Russian Federation has identified following key competences in the strategy for modernizing the content of general education (The Ministry of Education of the Russian Federation National Fund for Personal Training, 2001):

- Competences in the sphere of cognitive activities (methods of mastering strategies for acquiring knowledge from different sources of information)
- Competences in the sphere of socio-working activities (abilities to analyse and understand labour market, to evaluate personal professional abilities, etc)
- Competences in the household sphere (aspects of health, family well-being)
- Competences in culture-leisure activities (work-life balance).

There are some competences which correspond with the competences which are important for education in the sphere of sustainability, for example cognitive competence could include abilities for foresighted thinking and capacity to deal with uncertainties.
The modernization strategy was an attempt to move from content-based approach to the activity-based approach in teaching and learning (Pavlova, 2009). The strategy was followed by a national programme of education development 2006-2010 (Government of the Russian Federation, 2005). This programme was trying to close the gap between the skills demanded by the industry and the skills which were taught by the educational institutions (Pavlova, 2009). The dynamics of the educational development did not achieve expected results, therefore the identified problems have retained their relevance in the federal target program for educational development in 2011-2015 and state development program for 2013-2020 (Shirinkina, 2017). The reformation of the educational system was still continuing during these years and there were still problems in the balance between democratisation of the educational management and strict regulation of the universities' actions by federal and local ministries (Dzhurinskij, 2016). Another unresolved problem was the gap between the needs of labour market and the competencies of the graduates (Shirinkina, 2017).
In 2020 all levels of education are managed by federal state educational standards. There are several characteristics which are pre-defined for different study programs, for example the number of credits needed, duration of study, possible form of study (possibility of distant learning, e-learning), language of the studies, the competences which students are supposed to gain during the study. The competences are not strictly defined, they are just grouped in different themes and all of the themes should be covered by different disciplines, but the exact choice of the discipline is left to the university staff (The Ministry of Education of the Russian Federation, 2015).
All these political measures have prepared the base for the integration of sustainability into the education. In the Russian concept of transition to sustainable development it was highlighted that effective system of sustainability ideas promotion and creation of appropriate education and training system (Ukaz, 1996). The federal state educational standards also give a relative freedom for integration of sustainability into the study programs.
Ecological disciplines are quite often seen as a predecessors of sustainability education, for example, such disciplines as "Environmental protection and rational use of natural resources" (Azizova, 2015). In the beginning of 2000 ecological disciplines were divided in two main systems

– ecological education for classical universities (Ecology and resource use) and for technical majors (Environmental protection) (Kasimov et al., 2007). Some aspects of the sustainability were covered in these disciplines, but the core structure of sustainability including social, economic, and ecological aspects were missing.

All the attempts to introduce sustainability education in Russia are presented only on university level, school education is completely eliminated from this process (Azizova, 2015).

In 2012 there was an attempt to analyse a generalized picture of perception of sustainable development by key actors by Kirillov et al. (2012). According to this analysis, university teachers were more familiar with sustainability as school´s teachers. In schools the education for sustainable development has mostly environmental character, teachers were underlining waste issues and effective energy consumption and neglecting all other aspects of sustainability (Kirillov et al., 2012).

There are several universities which have introduced some courses with focus on sustainable development. Lomonosov State Moscow university is taking a special place among the educational institutions. It was one of the first institutions where a special section devoted to sustainability in the development programme of university (Ilin et al., 2017).

Despite od the fact that the topic of sustainability is permeating Russian educational system, Ilin et al. (2017) admit that until the topic of sustainability is not a part of state educational standards implementation and deployment issue of this form of education will not receive a radical solution and will be implemented as before on a residual basis.

Nevertheless, there are also some successful examples of the integration of sustainability topics into education, there were several projects financed by European Union with an aim to integrate the topics of rural sustainable development into agricultural education, examples of such projects are RUDECO (Rural development and ecology in Russia) and SARUD (Sustainable Agriculture and Rural Development) (Dieterich et al., 2018; Shindelov, 2017; Shindelov et al., 2019).

A project Sustainable Agriculture and Rural Development (SARUD) was financed by Erasmus+ and coordinated by the University of Hohenheim. The main aim of this project was development of a professional master program in sustainable agriculture and rural development at three Russian and three Kazakh agricultural universities (Dieterich et al., 2018). As a result, four Russian Universities have launched a master program with major in sustainability: Omsk State Agrarian University named after P.A. Stolypin, Michurinsk State Agrarian University, Buryat State Academy of Agriculture, Novosibirsk State Agrarian University.

An incentive for the SARUD project was a considerable lack of sustainable development strategies and integrated approaches for regional development, including skilled people (Dieterich et al., 2018). SARUD project was an attempt to fill the gap in education for decision makers and professionals in agriculture and related areas incorporating principles of sustainable rural development (Dieterich et al., 2018).

Education for sustainable development is a system providing life-long learning for all citizens and provide certain competencies which are essential for the promotion and facilitation of sustainable development and increase of the quality of living. It is clear that federal state educational standard does not declare a position which could contradict with the above-mentioned statements, but it does not mean that education for sustainability is integrated into Russian education (Dzyatkovskaya and Zahlebnyj, 2016).

The literature research on the topic of sustainable education in Russia is controversial, from one side there are evidences, that sustainability topics are often neglected or substituted with ecological education (Azizova, 2015; Ilin et al., 2017), from the other side there are examples of the projects which are integrating sustainability into different levels of education (Dieterich et al., 2018; Shindelov, 2017; Shindelov et al., 2019), and this topic is definitely interesting for deeper research and analysis.

2.9 Sustainability awareness

There is a presumed link between environmental education, public awareness of the environment and sustainable development (Holt and Barkemeyer, 2012). The last 20 years have seen a change in the prominence of environmental and social issues within the public sphere and the corporate world often facilitated media coverage on television, in newspapers and online; environmental messages and social issues are also communicated through more structured channels as school curricula and environmental education programmes (Holt and Barkemeyer, 2012).

Sustainability awareness is important not only on an academic level, but also on a level of broader public. That is why it is important that sustainability topics are integrated into school education. According to research results in Buryatia (Russia) only 3% of schoolteachers were familiar with the international documents concerning sustainable development, only 2 % could define the term sustainability (Haludorova, 2017).

There is a clear gap between official adoption of sustainability development goals and its implementation, and there is a need for additional trainings for teaching staff in educational organisations.

The SDG number 12 is the responsible consumption and production, according to Sustainability report 2019, Russian federation must overcome significant challenges to reach this goal (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019).

Sustainable consumption means that consumer perceives a direct link between what is consumed and the social issue itself (Verbeke et al., 2007). To ensure responsible consumption it is very important to rise population awareness of the sustainability issues.

Many authors are admitting the importance of building public awareness of sustainability (Alabaster and Hawthorne, 1999; Crotty and Hall, 2014; Herremans and Reid, 2010; Kasimov et al., 2007). Sustainability awareness is supposed to encourage individuals to take account of environmental costs in their lives (Alabaster and Hawthorne, 1999).

Media is playing an important role in this process, for example in setting the climate change discourse and providing that the discourse reaches the public (Givel, 2006; Ryghaug, 2011).

After Soviet Union collapsed a 1993 poll revealed that 88% of Russian citizens rated environmental quality as poor, between 2001 and 2007 60 % of Russians perceived a decline in environmental quality, but only 9 % felt that it was Russia´s most pressing problem (Henry and Douhovnikoff, 2008). Another study in 2008 showed that 78 % of citizens are concerned about environment, but these concerns are not linked to action or priority (Henry, 2010).

This is the issue, which needs attention in Russia, there are some attempts to rise citizens´ awareness. For example, there is an open school for sustainable development, which is promoting the SDGs and making online courses and webinars, holding lectures and publishing articles for a broader public. It has an aim to form the understanding of sustainable development concept and raise public awareness (SDG.Openshkola.org, 2019). But there is still a room for improvement, the work of raising the awareness of sustainability concept should be started with educational institutions and it should be accompanied by the initiatives involving more citizens.

However, there is still no basic document (doctrines, strategies etc.) in the field of environmental education and awareness for sustainable development in the Russian Federation (Ryazanova, 2018). The main idea of introduction of the SDGs into the educational process is to provide that the specialists from different fields understand and consider problems and possibility of their occurrence during determination of development strategies in different branches of the national economies.

In Russia it is quite often the case that strategical decisions are taken by the people, who did not have special training in sustainable development, and this problem generates all the rest including the lack of consideration of possible consequences. That is why sustainability education for decision makers is a crucial issue which is determining the attitude of future managers and decision-makers.

2.10 Conclusion

Sustainability is a complex concept and there are different methods to measure if the development of a region or a country is sustainable. Since Club of Rome and Brundtland report scientists are trying to develop a transparent methodology. After 30 years of research there is no one-method-fits-all methodology, there are some measures like HDI when it is possible to compare different countries between each other, but as the conditions of the regions and definitions of sustainability vary, it makes sense to customise the sustainability assessment methods. Even within such a big country like Russia the differences between the regions could be huge, and it is important that the methodologies are flexible and there are possibilities to adapt them to different regions.

Russia is the largest country in the world, it is rich in natural resources, and unsustainable development of the Russian Federation can become a threat not only to Russia itself, but also to the whole world. Therefore, it is so important to explore the possibilities of assessing the sustainability of development specifically for Russian conditions.

Russia is an interesting subject for research, it has its own history of integrating sustainability principles to the policymaking, but the sphere of sustainability assessment is lagging, and when the sustainability is included into the legislative rhetoric it does not result in the actions directed to sustainable development. Another problem is the fact that the sustainability concept includes ecological, economic, and social aspects, as a result the legislative acts as well as departments responsible for sustainability are scattered and quite often, they lack effective communication, and their collaboration is poorly coordinated. There is a clear need for applicable and transparent methodology for the sustainability assessment on regional level that could be easily interpreted by different departments, and it could be used for better understanding between them.

Another important issue is the sustainability education, it is already clear that to provide sustainability in future it is important to raise awareness of sustainability issues among citizens as well as among policymakers. Sustainability education is supposed to serve this aim, as was stated by UNESCO report (2017) the approach of Education for Sustainable Development empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability, and therefore education is playing a crucial role in reaching sustainability.

There are some examples that education for sustainability has entered Russian curriculums, but there is still room for development, as many experts are admitting there are several problems. Firstly, it is quite often that sustainability education is confused with ecological education, and all other aspects of sustainability are neglected, and it is important to research if it is the case in Russian educational institutions and to find out how the integration process should be changed to solve this problem. Secondly, sustainability topics are only present in higher education (often only on master level), school education is not considered at all. Thirdly there are limited opportunities for teaching staff training.

From one side it is of crucial importance to evaluate and monitor sustainability, but from the other side even if the monitoring system is well established there is a need for qualified staff who can analyse the results of monitoring. That is why it is important to research both topics: sustainability assessment and education for sustainability in Russia.

Methodological framework

3.1 Introduction

There are two main research aims of this dissertation – investigating possibilities for sustainability assessment and investigating the education for sustainability in Russia.

This chapter presents the research design, data collection and data analysis procedures and the choice of suitable methods for addressing the formulated research questions. Not only will practical procedures be presented, but their theoretical fundaments will also be discussed in the following part of the dissertation.

3.2 Composite indicator for sustainability assessment

One of the research aims is to establish the sustainability assessment procedure, it is important to analyse possibilities for composite indicator creation. There is a diversity of methods and tools to assess and report sustainable development, however, indicators are one of the approaches most used (Pope et al., 2017b; Ramos, 2019; Sala et al., 2015).

This approach is innovative for Russian condition as there

OECD has elaborated a procedure for composite indicator creation and it is proceeding in following order (Nardo et al., 2008)

1. Developing theoretical framework
2. Indicator selection
3. Multivariate analysis
4. Imputation of missing data
5. Normalization of indicators
6. Indicators weighting
7. Robustness and sensitivity
8. Links to other variables
9. Decomposition
10. Presentation

Each step of composite indicator creation can be performed with different methods, and because one of the aims of this work is to establish the procedure of creating composite indicators out of sub-indicators, it is important to perform comparison between composite indicators created with different methods. For example, it is interesting to see how significant in terms of regional indicators the selection of normalization or weighting techniques is. The choice and use of the different methodologies are often debated in the scientific literature, however as long as purpose of the index and its indicators and weights are clearly specified and justifies, robustness test are performed and the indicator is open to public scrutiny and revision composite indicators can prove invaluable in development studies (Santos and Santos, 2014). But indicators should fulfil certain feasibility criteria, European Environmental Agency has developed a set of criteria which included policy relevance, existence of targets, methodological advancement, data availability, possibility of assessment trends, spatial coverage, and comparability between countries/regions (Hak et al., 2012). Another important criterion is cost of collection, as in the most cases the data should be collected regularly.

3.2.1 Developing theoretical framework

To create a composite index out of the set of indicators the components of such index should be chosen. The determination of the components should be based on theory, empirical analysis, pragmatism or intuitive appeal, or some combination thereof (Singh et al., 2009).

Gómez-limón & Sanchez-fernandez (2010) also state that selection of indicators should be based on strict quality criteria and accurate data gathering. To manage the huge amount of possible indicators and data required, it is therefore advised that a solid theoretical framework should be

utilised (Blanc et al., 2008; Gómez-limón and Sanchez-fernandez, 2010). Therefore, a sound theoretical framework is the starting point in constructing composite indicators (Nardo et al., 2008). Ideally theoretical framework should clearly define the phenomenon to be measured and its sub-components. It should give an opportunity to select indicators and their relative weights and dimension in the composite indicator. Unfortunately sometimes in reality, this process is not based on the what is desirable to measure, but on which indicators are available (Nardo et al., 2008).
In the OECD handbook on constructing composite indicators following issues should be regarded in order to provide maximal transparency in the constructing of credible indicators (Nardo et al., 2008):

- definition of the concept should give a clear impression what is measured
- determining the sub-groups is helping to divide complex multi-dimensional concepts into independent sub-themes
- selection criteria for the underlying indicators should work as a guide for whether an indicator should be included or not into overall composite index.

The proper definition of the theoretical framework affects the relevance of the composite indicator, but also its credibility and interpretability. Also, these steps are important to provide transparency in the sustainable development research. As it is in "a risk group" of subjectively measured phenomenon, because economic research in this field is still being developed (Nardo et al., 2008).
The following notation is used in the following chapters:
x_{qc}^{t}: raw value of individual indicator q for region c at time t, with q=1, …, Q and c=1, …, M.
I_{qc}^{t}: normalised value of individual indicator q for country c at time t.
w_{rq}: weight associated to individual indicator q, with r=q, …, R denoting the weighting method.
CI_{c}^{t}: value of the composite indicator for country *c* at time t.

3.2.2 Indicator selection

During an assessment process following question arises: "What is needed to be assessed and how it could be assessed?" Therefore, selection and weighting of indicators should be based on theoretical concept. Even with fundamental theoretical background the selection of indicators will be value-loaded.
The strengths and weaknesses of composite indicators is highly dependent on the quality of underlying variables. There is no fully objective, formalized procedure on the selection of indicators (Nardo et al., 2008; Saisana et al., 2005). The process of indicator selection is always a compromise between data availability and idealistic ideas which indicators are measuring the phenomenon. As a result of such compromise qualitative data from surveys or policy reviews is often included into composite indicators (Nardo et al., 2008).
For instance, an inventory report of UNDP identifies over 400 official composite indices that rank or assess a country according to some economic, political, social, or environmental measures and a complementary report by the United Nations' Development Programme documents over 100 composite measures of human progress (Bandura, 2011; Yang, 2014). And there is a clear increase in the amount of scientific publications on the topic of composite indicators (Greco et al., 2019). It is confirming the fact that research has produced numerous indicators that are helping policy-makers to see if the country or the region is on the track to sustainable development and to communicate the outcomes of the research to the stakeholders (Sala et al., 2015).
There are examples of composite indicators, which are based on just few sub-indicators (Human development index) or composite can consist of few hundreds of sub-indicators (Worldwide governance indicator with over 300 indicators from 33 separate data sources) (Kaufmann et al., 2009). The amount of underlying indicators is set by the character of the phenomena (Foa and Tanner, 2012).
Panda et al. (2016) have created an aggregated index for the assessment of the sustainable development of India, different global initiatives measuring sustainability was used as a theoretical

framework for this index: Social progress Index (Stern et al., 2014), Global Urban indicator database (UN-Habitat, 2014), MDGs (UN-Habitat, 2014), FEEM Sustainability index (Carraro et al., 2009) and others. Out of all of this initiative common indicators were gathered, and 47 indicator for which good quality affordable data was available were analysed with factor analysis on the subject of collinearity and consistency (Panda et al., 2016).
However use of unstructured sets of indicators may result in biased and unrealistic assessment of a certain policy (Olsson et al., 2009). Careful selection of indicators is needed to create a realistic picture of sustainable development. Also attention should be paid to the interactions (possible synergies and trade-offs) between the indicators (Olsson et al., 2009). Indicators should serve as an instrument which helps understanding those interactions, thus which policy action is leading to which outcome (Passel et al., 2006).

3.2.3 Multivariate analysis

After suitable indicators are selected, there is a need to check how well the data is structured. Multivariate analysis is serving an aim to check if there are interrelations between the indicators. It helps to avoid overwhelming, confusing and misleading signals for decision-makers and general public (Nardo et al., 2008).
Both bivariate and multivariate statistical techniques are employed where selection is based on empirical analysis (Singh et al., 2009). Bivariate analysis helps to measure the strength of the association between all pairs of variables, and it traditionally employs correlation matrices in selection. Multivariate technique evaluate the overall power of any collection of variables to measure any other variable (Singh et al., 2009).
The specific goal of principal component analysis and factor analysis is:

- to summarize patterns of correlations among observed variables
- to reduce many observed variables to a smaller number of components or factors
- to provide an operational definition for an underlying process by using observed variables
- to test theory about the nature of underlying processes (Tabachnick and Fidell, 2007).

Principal component analysis could be used for identifying the dimensionality of phenomenon, for clustering and for weighting of indicator (Saisana et al., 2005). Principal component analysis was first described by Pearson in 1901, followed by practical computing methods written by Hotelling in 1933 (Saisana et al., 2005).
The aim of analysis is to take p variables X_1, X_2, …, X_p and find linear combination of these to produce principal components Z_1, Z_2, …, Z_p that are uncorrelated (Saisana et al., 2005).

$$Z_j = \sum_{i=1}^{p} a_{ij} X_j \, , J = 1,2, \dots , p \qquad (1)$$

Lack of correlation between components of composite indicator is a positive sign. It is showing that sub-indicators are measuring different statistical dimensions (Nardo et al., 2008). Principal component analysis is helping to reduce the large number of variables, leaving only variable, which do not correlate. It should be stressed that, when there is no correlation between indicators this tool is of no value (Nardo et al., 2008).
The weights a_{ji} applied to the variables X in equation (1) are chosen in such a way so that principal component Z satisfy following conditions (Saisana et al., 2005):

1. they are uncorrelated (orthogonal)
2. the first principal component accounts for the maximum possible proportion of the variance of the set of X's, the second principal component accounts for the maximum of the remaining variance and so on until the last of the principal component absorbs all the remaining variance not accounted for by the preceding components.

3. $a_{1j}^2 + a_{2j}^2 + \cdots + a_{pj}^2 = 1, j = 1,2, \ldots, p.$

The correlation coefficient between the principal components Z and the variables x are called component loadings, r (Z_j, x_i). In the case of uncorrelated variables x, the loadings are equal to the weights a_{ij} given in the equation 1. The square loading is the percentage of variance that variable explained by the principal component and the component scores are the scores of each case on each principal component (Nardo et al., 2008).

Factor analysis has similar aims as PCA. It is general idea is that phenomenon could be described with less factors and consequently explain the relationship between the factors. An important difference is the fact that PCA is not based on any specific statistical model, but factor analysis does (Saisana et al., 2005). Contrary to PCA the factor analysis model assumes that the data is based on the underlying factors of the model, and that the data variance can be decomposed into that accounted for by common and unique factors. Also PCA merely decomposes the original data into a set of linear variates (Field, 2009).

Table 3.1 Strength and weakness of multivariate analysis

	Strengths	Weaknesses
Principal components /Factor analysis	Can summarise a set of sub-indicators while preserving the maximum possible proportion of the total variation in the original data set. Largest factor loadings are assigned to the sub-indicators that have the largest variation across countries, a desirable property for cross-country comparisons, as sub-indicators that are similar across countries are of little interest and cannot possibly explain differences in performance.	Correlations do not necessarily represent the real influence of the sub-indicators on the phenomenon being measured. Sensitive to modifications in the basic data: data revisions and updates, *e.g.*, new countries. Sensitive to the presence of outliers, which may introduce a spurious variability in the data. Sensitive to small-sample problems, which are particularly relevant when the focus is on a limited set of countries. Minimisation of the contribution of sub-indicators, which do not move with other sub-indicators.
Cronbach coefficient Alpha	Measures the internal consistency in the set of sub-indicators, *i.e.*, how well they describe a unidimensional construct. Thus, it is useful to cluster similar objects.	Correlations do not necessarily represent the real influence of the sub-indicators on the phenomenon expressed by the composite indicator. Meaningful only when the composite indicator is computed as a "scale" (i.e., as the sum of the sub-indicators).
Cluster analysis	Offers a different way to group countries; gives some insight into the structure of the data set.	Purely a descriptive tool; may not be transparent if the methodological choices made during the analysis are not motivated and clearly explained.

Source: Nardo *et al.*, 2005

Also test for consistency should be performed. Internal consistency is analysing the reliability of the data set to evaluate what they are supposed to evaluate. Cronbach`s Alpha is usually used to measure internal consistency (Terziovski and Guerrero, 2014). By internal consistency is meant how well the set of sub-indicators is measuring unidimensional object (Nardo et al., 2008). It measures the portion of total variability of the sample of sub-indicators due to the correlation of indicators. It increases when the number of indicators is growing and so is the covariance of each pair. When there is no correlation und variables are independent than C-Alpha is equal to zero, in case of perfect correlation it equals one (Nardo et al., 2008). Cronbach-Alpha is not a statistical test, but a test of reliability based on correlations between variables.
Cluster analysis is a collection of algorithms to classify objects (Nardo et al., 2008). As principal component analysis it also has an aim to reduce the dimensionality of data set by identifying similarities/dissimilarities.
In the table 3.1 main strengths and weaknesses of multivariate analysis are presented.
Anyway indicator selection process is value-laden and despite the claims that value-judgments and cultural issues should be avoided the process will remain subjective (Singh et al., 2009).
Singh et al. (2009) is also adding discriminant as a notable multivariate technique, which could be employed in composite indexing. The result of this step should be the analysis of suitability of the data set.

3.2.3.1 Preliminary analysis

Multivariate analysis is done with help of principal component analysis and factor analysis. There are few basic assumptions, which are important for this analysis. The aim of the preliminary analysis of data set is to determine that multivariate analysis is appropriate technique (Tinsley and Tinsley, 1987).
First assumption is considering sample size. There is no consistency on sample size for principal component analysis and factor analysis (Nardo et al., 2008):

- The cases-to-variables ration should be no lower than 3 (Grossman et al., 1991)
- The cases-to-variables ration should be no lower than 5 (Bryant and Yarnold, 1995)
- The number of cases should be between 5 multiplied by number of variables and 100 (Hatcher, 1994)
- At least 200 cases, regardless of the cases-to-variables ratio (Gorsuch, 1983)
- At least 150-300 cases, more toward 150 when there are a few highly correlated variables (Hutcheson and Sofroniou, 1999)
- 51 more cases than the number of variables, to support chi-squared testing (Lawley and Maxwell, 1971).

According to Tinsley and Tinsley (1987) “the larger the sample, the better”. Also some authors combine few rules: for example the cases-to-variables ration and the rule of at least 200 variables (Bryant and Yarnold, 1995).
Selection process of sub-indicators should be as less biased as possible (Nardo et al., 2008). As inclusion of irrelevant sub-indicators and exclusion of relevant ones are often leading to erroneous results instead of „cleaner solution“ (Kim and Mueller, 1978).
The presence of outliers can affect interpretation of result of PCA/FA, that is why outliers should be identified and removed prior to the analysis (Nardo et al., 2008).
To avoid one variable having an undue influence on the principal components, Nardo et al. (2005) recommends standardizing the variables to have zero means and unit variance at the start of the analysis.
Before PCA or factor analysis could be performed the correlation between the indicators should be checked, when the indicators do not correlate with each other there is no use in PCA. As Tabachnick & Fidell (2007) suggest, to be considered suitable for factor analysis, the correlations

should be at least 0.3 or greater. Multicollinearity exists when the variables are highly correlated (r=0.9 or above) (Tabachnick and Fidell, 2007).
The correlation matrix contains the Pearson correlation coefficient between all pair of the indicators. It should be used to check the pattern of the relationships. When correlation coefficient is greater than 0,9, then a problem of singularity in data could arise. According to Tabachnick and Fidell (2007) multicollinearity and singularity are problems with a correlation matrix that occur when variables are too highly correlated. With multicollinearity, the variables are very highly correlated (0,9 and above); with singularity the variables are combinations of two or more of the other variables (Tabachnick and Fidell, 2007).
Multicollinearity and singularity are causing both logical and statistical problems. At this step the variables with multicollinearity should be excluded. A signal for multicollinearity is a particular summary measure of the correlation matrix called the determinant (it should be greater than 0,00001) (Field, 2009).
Bo & Woo (2008) are suggesting for overcoming the problem of multicollinearity to use a two or multistage PCA. At first, the highly correlated indicators should be grouped, and a composite sub-index should be constructed out of it, and then this sub-index should be used to construct the final composite index.
Then the Kaiser-Meyer-Olkin measure of sampling adequacy (usually called MSA or KMO) should be applied (Field, 2009). The KMO can be calculated for individual and multiple variables and represents the ration of the squared correlation between variables to the squared partial correlation between variables. It varies between 0 and 1, a value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations. A value close to 1 indicates that pattern of correlations are relatively compact and factor analysis should yield distinct and reliable factors (Field, 2009).
Kaiser (1974) suggests value greater than 0,5 as barely acceptable (with lower values more data should be collected or another variables included) (Kaiser, 1974). Values between 0,5 and 0,7 are mediocre, values between 0,7 and 0,8 are good, values between 0,8 and 0,9 are great and values above 0,9 are superb (Hutcheson and Sofroniou, 1999). According to Tabachnick & Fidell (2007) Kaiser`s measure should be above 0,6 for good factor analysis.
Bartlett test of Sphericity is a notoriously sensitive test of the hypothesis that the correlations in a correlation matrix are zero (Tabachnick and Fidell, 2007). Bartlett test of Sphericity compares the correlation matrix with a matrix of zero correlations (technically called the identity matrix). The result of this test should be a small p value, which means that it is highly unlikely to obtain the observed correlation matrix from a population with zero correlation (Norman and Streiner, 2007). According to Tabachnick & Fidell (2007) the result of the test higly depends on the sample size, and with substantial size the correlation is very likely to be significant. Therefore, there is a recommendation to use it only is there are fewer than five cases per variable.

3.2.3.2 Performing the analysis

After preliminary analysis is conducted then following questions should be addressed (Tinsley and Tinsley, 1987):

- Which method of factor extraction to use?
- Which communalities estimate should be used?
- Which method should be used for factor scores calculation?
- How many factors to rotate?
- Which rotation procedure to use?

There are several methods to discover factors in the data set, the choice of method depends on the aims of the analysis (Field, 2009). Tinsley and Tinsley (1987) grouped the factor extraction methods according to assumptions the researcher makes regarding the sampling of subjects and variables and whether the factor analysis is exploratory or is intended for hypothesis testing. In the table 3.2 the summary of this classification is presented.

In exploratory methods of factor extraction researchers aim is to generalize the findings from the sample to a population and in confirmatory the purpose is to test a hypothesis (Field, 2009). Both types could be descriptive – findings could be applied to the sample collected, or inferential – could be generalized to a population (Field, 2009; Tinsley and Tinsley, 1987).
According to Tinsley and Tinsley (1987) when using the exploratory-descriptive methods researchers are assuming that both subjects and variables to be populations, thereby to simplify the deriving the mathematical equations to constitute the procedures. Consequently, descriptive procedures and generalization based on a single analysis is prohibited, generalization of results from these procedures to new variables requires replication, the only exception is when analysis on several samples with similar variables reveals the same factor structure (Field, 2009; Tinsley and Tinsley, 1987).

Table 3.2 Methods of factor extraction

Type	Descriptive	Inferential
Exploratory	Principal components Principal factors Image analysis Minimum residual analysis	Canonical factor analysis Maximum likelihood Alpha factor analysis
Confirmatory	Multiple group Lisrel	Confirmatory maximum likelihood Lisrel

Source: Tinsley and Tinsley, 1987
Exploratory-inferential methods assume that the subjects are randomly sampled, but the variables constitute the total population of variables (Tinsley and Tinsley, 1987). However, a constraint is that any findings hold true only for the set of variables measured (Field, 2009).
When confirmatory methods are use, the researcher is supposed to formulate the hypotheses stating exact number of factors to be extracted. The factor analysis then tests if the data fits to these hypothesized factors (Tinsley and Tinsley, 1987).
The choice of the method depends mostly on what kind of generalization is desired (Field, 2009) and if the analysis is aimed to be exploratory or hypothesis testing (Tinsley and Tinsley, 1987).
Another important question that should be answered is: "Which communalities estimate should be used?" Communalities is the proportion of common variance present in a variable, meaning how much variance can be explained by the retained factor (Field, 2009). The variance of item or a test consists of common, specific and error variance. Common variance is common to at least one of other variables (Tinsley and Tinsley, 1987). As purpose of multivariate analysis is to find common underlying dimensions within the data the primer interest is in common variance. The most widely used method is the square multiple correlations of each variable with all others (Field, 2009; Tinsley and Tinsley, 1987).
Also question which method should be used for factor scores calculation should be answered. Factor scores represent a composite score for each indicator on a particular factor (Field, 2009).
There are several methods for calculating factor scores: regression method, the Bartlett method and the Anderson-Rubin method (Field, 2009). Different methods are yielding different result, which cannot be compared. The simplest method is the regression method. In this method the factor loadings are adjusted to take account of the initial correlations between variables, in doing so, differences in units of measurements and variable variances are stabilized. The Bartlett method produces scores that are unbiased and that correlate only with their own factor. The mean and standard deviation is the same as in regression method. The Anderson-Rubin method is a modification of Bartlett method that produces factor scores which are uncorrelated and standardized (they have mean of 0 and standard deviation of 1). Tabachnick and Fidell (2007) are

recommending Anderson-Rubin method when uncorrelated scores are required. But according to Field (2009) regression method is often used, because it is the most easily understood, but it should be used only when correlation between factor scores is acceptable.
Afterwards the decision, how many factors should be retained, should be taken. There are different opinions of scientists how to limit lost information after retaining the factors (Nardo et al., 2008). There are various guidelines ("stopping rules") (Dunteman, 1989):

- Kaiser criterion. Retain only those principal components with variance larger then 1 (Jolliffe, 2002). All the components with eigenvalues below 1 should be dropped. The explanation is that it does not make sense to add a component that explains less variance than is contained in one sub-indicator (Nardo et al., 2008)
- Scree plot. This is a graphical method, which was proposed by Cattel (1966). The plot presents the successive eigenvalues, which drop off sharply and then tend to level off. The methods suggests retaining all eigenvalues in the sharp descent before the first one on the line where they start to level off (Cattell, 1966; Nardo et al., 2008)
- Variance explained criteria. Some researchers simply use the rule of keeping enough components to account for 90 % (sometimes 80%) of the variation (Nardo et al., 2008)
- Joliffe criteria. Drop all the components with eigenvalues under 0,70 (Jolliffe, 2002). This rule may result in twice as many components as the Kaiser criterion and it is less often used (Nardo et al., 2008)
- Comprehensibility is limiting the number of components to those whose dimension of meaning is readily comprehensible (Nardo et al., 2008).

The next step after choosing the number of factors to keep is the rotation. Rotation is enhancing the interpretability of the results (Abdi and Williams, 2010; Kline, 1998). The sum of eigenvalues in not affected by rotation, but changing the axes, will alter the eigenvalues of particular components and will change component loadings (Nardo et al., 2008).
According to Abdi & Williams (2010) the rotation will facilitate the interpretaion in case that the data is following a model stipulating:

1. That each variable load only on one factor
2. That there is a clear difference in intensity between the relevant factors.

Then the rotation is likely to provide a solution that is more reliable than the original solution. However is this model does not accurately represent the data, then the interpretation of the results will not be facilitated, but make it less replicable and harder to explain, because mathematical properties of PCA have been lost (Abdi and Williams, 2010).
SPSS package is offering three methods of orthogonal rotation varimax, quartimax and equamax, and two methods of oblique rotation – direct oblimin and promax (Field, 2009). Overall goal of rotation is to get a clear pattern of high loadings for some variables and low for others. The concept of factor loadings refers to the correlation between the variables and the factors (Krishnan, 2010).
The most common rotation method is the "varimax rotation" developed by Kaiser (1958) (Abdi and Williams, 2010; Nardo et al., 2008). The varimax is a variance maximizing strategy where the goal of rotation is to maximize the variance (variability) of the components (Krishnan, 2010). For varimax a simple solution means that each component has a small number of large loadings and many small loadings. After rotation each original variable tends to be associated with one of components, and each component represents only a small number of variables (Abdi & Williams 2010).
Quartimax rotation is the opposite of varimax rotation and it attempts to maximize the spread of factor loading for variable across all factors (Field, 2009). Equamax is a hybrid of the quartimax and varimax rotations that tries simultaneously to simplify the factors and the variables. Thus, varimax rotation simplifies the factors, quartimax the variables, and equamax both (Tabachnick and Fidell, 2007).
Oblique rotations offer a continuous range of correlations between factors. The maximum amount of permitted correlation is determined by a variable called delta by SPSS factor (Tabachnick and

Fidell, 2007). When delta is greater than 0, then highly correlated factors are expected, when it is smaller than 0 then less correlated factors are expected (Field, 2009). The factors do not necessarily correlate when an oblique rotation is used, and often when they do not correlate the researcher reports the simpler orthogonal rotation. Direct oblimin is the family of procedures used for oblique rotation with varying degrees of correlation (Tabachnick and Fidell, 2007). In promax rotation an orthogonally rotated solution is rotated again to allow correlations among factors (Tabachnick and Fidell, 2007). According to Abdi & Williams (2010) the promax rotation has the advantage of being fast and conceptually simple.

According to Field (2009) the choice of rotation method depends on whether the underlying factors should be related. When the factors are expected to be independent, then orthogonal rotation should be used (Field (2009) recommends varimax). If there are expectations, that extracted factors will be correlated, then direct oblimin is recommended by Field (2009).

Once the factor structure has been found, it is important to decide which variables make up which factors. Usually the factor loadings with absolute value greater than 0,3 are considered to be important (Field, 2009).

The result of multivariate analysis should be conclusions about data structure and its suitability for factor analysis. The sub-groups of indicators should be identified and compared to the theoretical framework. When the data is suitable for principal component analysis, the factor loading, and components could be used for weighting procedure.

3.2.4 Imputation of missing data

Composite indices can deal with missing data in three ways (Foa and Tanner, 2012):

- Deletion of cases pairwise
- Imputation of missing data
- Use of existing data sources.

Case wise deletion means that regions or countries with missing data are completely excluded from the analysis; also, this strategy could be used for the indicators for which the data is incomplete for the full set of regions or countries. For example, HDI selects the variables for which complete data across the domain of countries is relatively easy to obtain. This method of deletion is highly influenced by data availability and in some cases it can lead to serious reduction of sample size (Foa and Tanner, 2012).

The second way to deal with missing data is to impute the missing values, there are several methods available – mean substitution, correlation results, time series (Saisana et al., 2005).

Imputation methodologies usually use predictive distributions of the missing values (Little and Rubin, 2002). The predictive distribution could be generated with implicit or explicit modelling. Implicit modelling is an algorithm with implicit underlying assumptions that need to be verified whether they are reasonable and fit to the issue under consideration (Nardo et al., 2008). In implicit modelling the missing values are substituted with similar responding units (hot deck imputation), with units not selected to the sample (substitution) or with values from external source (cold deck imputation) (Nardo et al., 2008). Explicit modelling is based on a formal statistical model – unconditional mean/median/mode imputation, regression imputation or expectation maximization.

It is very likely that the choice of method of data imputation will influence the result. Nardo et al. (2005) admits: that the danger lies in the fact that after data imputation data set is treated as complete. Also imputation methods are systematically underestimating the variance of the estimated, therefore these methods does not fully assess the implication of imputation (Nardo et al., 2008).

Last method is the most preferable, but only in the case when enough data is available. When statistical data is limited than the imputation method should be chosen and robustness test should be performed (Foa and Tanner, 2012).

3.2.5 Normalization of indicators

Transforming base indicators into unidimensional variables (normalization) is required before an aggregation (i.e. to make indicators mathematically operational) (Gómez-limón and Sanchez-fernandez, 2010; Nardo et al., 2008). For this purpose the use of multiple-attribute utility theory and reference values (sustainability levels that determine the minimum/maximum values of the indicator values) are suggested (Gómez-limón and Sanchez-fernandez, 2010).

According to Ebert and Welsch (2004) normalisation is in most cases a linear transformation of crude data, involving two elementary operations of translation and expansions. In practice indicators are ranged and standardized. By ranging is meant that the data is scaled into the interval 0 to 1 by expressing them relative to some reference value and in standardization, indicators are obtained by subtracting the mean from the observations and dividing by the standard deviation (Ebert and Welsch, 2004).

There are several options of normalization of indicators. The objective is to identify the most suitable normalization procedure to apply to a certain problem, taking in respect the measurement units of the indicators and their robustness to possible outliers in the data (Ebert and Welsch, 2004; Nardo et al., 2008).

According to Nardo et al. (2005) different normalization techniques can yield same normalized value irrespective of the measurement unit. However, normalization procedure, which is not invariant to changes in the measurement unit can result in different outcomes.

The first option is in not scaling variables, it is suitable in a case when variable are already scaled (Singh et al., 2009).

The second option is the use of standard scores (z and t values). Standardization (z-scores) converts indicator to a common scale with a mean of zero and standard deviation of one. Indicators with extreme values have a great effect on composite indicator (Nardo et al., 2008). Z-score is the most commonly used approach because it has desirable characteristics for aggregation (Freudenberg, 2003). With help of this method all the variable are converted into common scale with an average of zero, which avoids aggregation distortions stemming from differences in variable means (Freudenberg, 2003).

For each sub-indicator x_{qc}^{t}, the average across regions $x_{qc=\bar{x}}^{t}$ and the standard deviation across regions $\sigma_{qc=\bar{c}}^{t}$ are calculated. The normalization formula is:

$$I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc=\bar{c}}^{t}}{\sigma_{qc=\bar{c}}^{t}} \qquad (2)$$

so that all the I_{qc}^{t} have similar dispersion across regions (Nardo et al., 2008). For time-dependent studies, to assess region performance across years, the average across regions $x_{qc=\bar{c}}^{t_o}$ and the standard deviation across regions $\sigma_{qc=\bar{c}}^{t_o}$ are calculated for a reference year, usually the initial time point, t_o.

Z-score method is converting variable to a common scale with an average of zero and it avoids introducing aggregation distortion stemming from differences in variable means (Freudenberg, 2003). This approach has been used in construction of may composite indicators such as a composite of investment in the knowledge base economy or a country´s capacity to create knowledge (Muldur, 2001) and the environmental sustainability index (World Economic Forum, 2002).

The third option is the transformation of variables in to ordinal response scales (Singh et al., 2009). In other words, variables are ranked. Ranking is the simplest normalization technique. This method is not influenced by outliers and it gives an opportunity to follow the development over time in terms of relative positions (Nardo et al., 2008). Another type of ranking is assignation of categorical scale for each indicator. Category could be both numerical and qualitative ("not achieved", "partly achieved" and "fully achieved"). Categorical scale excludes large amount of information about the variance of indicators and makes it difficult to follow improvement over time (Freudenberg, 2003; Nardo et al., 2008).

The fourth option is the conventional linear scaling transformation or re-scaling (also called min-max standardization) normalizes the indicators to have the identical range (0;1). This requires points of reference relative to which indicators can be scaled. A minimum and a maximum value are usually identified for each of the variables (Singh et al., 2009). For example United States and Japan are used as an external benchmark country built in the framework of EU Lisbon agenda (Nardo et al., 2008).
Each indicator x_{qc}^t for a generic region c and time t is transformed in

$$I_{qc}^t = \frac{x_{qc}^t - min_c(x_q^t)}{max_c(x_q^t) - min_c(x_q^t)} \qquad (3)$$

Where $min_c(x_q^t)$ and $max_c(x_q^t)$ are the minimum and the maximum value of x_{qc}^t across all the regions c at time t. In this way, the normalized indicator I_{qc}^t have values laying between 0 (laggard, $x_q^t = min_c(x_q^t)$) and 1 (leader $x_q^t = max_c(x_q^t)$).
The expression

$$I_{qc}^t = \frac{x_{qc}^t - min_c(x_q^{t_o})}{max_c(x_q^{t_o}) - min_c(x_q^{t_o})} \qquad (4)$$

Is sometimes used for time-dependent studies. However, if $x_q^t > max_c(x_q^{t_o})$, the normalized indicator y_q^t will be larger than 1 (Nardo et al., 2008).
Another possibility of the re-scaling method is

$$I_{qc}^t = \frac{x_{qc}^t - min_{t\in T} min_c(x_q^t)}{max_{t\in T} max_c(x_q^t) - min_{t\in T} min_c(x_q^t)} \qquad (5)$$

Where the minimum and maximum for each indicator is calculated across regions and time to consider the evolution of indicators. However, those indicators are not stable and the composite indicator should be recalculated when new data is available (Nardo et al., 2008). Extreme values or outliers could distort the transformed indicator, but on the other hand re-scaling could widen the range of indicators lying in small interval. In that case the effect of these indicators on composite index will increase more than if the z-scores transformation would be used.
Another method is distance to a reference. This method takes the ratios of the indicator x_q^t for a generic region c and time t with respect to the sub-indicator $x_{qc=\bar{c}}^{t_o}$ for the reference region at the initial time t_o.

$$I_{qc}^t = \frac{x_{qc}^t}{x_{qc=\bar{c}}^{t_o}} \qquad (6)$$

The denominator $x_{qc=\bar{c}}^{t_o}$ the transformation considers the evolution of indicators across time.
Nardo et al. (2005) offers an option to consider the region itself as reference region and calculate the distance in terms of the initial time point as

$$I_{qc}^t = \frac{x_{qc}^t}{x_{qc}^{t_o}} \qquad (7)$$

Freudenberg (2003) is offering to use distance from the group leader by assigning 100 to the leading country and ranking other countries as percentage points away from the leader. Also mean, best or worst performer could be used as a reference value (Freudenberg, 2003). Freudenberg (2003) criticizes the distance to extreme values, as it can be based on unreliable outliers.
Another transformation which considers the indicators that are above or below a defined threshold is the indicators above or below the mean (Freudenberg, 2003; Nardo et al., 2008):

$$I_{qc}^t = \begin{cases} 1 & if\ w > (1+p) \\ 0\ if\ (1-p) \le w \le (1+p), where\ w = x_{qc}^t / x_{qc}^{t_o} & \\ -1 & if\ w < (1+p) \end{cases} \qquad (8)$$

With this kind of normalization, a neutral region around the mean is build, where transformed indicator is equal to zero. For time-dependent studies to assess regions performance over time, the average across regions $x_{qc=\bar{c}}^{t_o}$ is calculated for a reference year (usually t_o) (Nardo et al., 2008).
According to Freudenberg (2003) variables are normalised to avoid having extreme values dominate and to partially correct for data quality problems. The data with values extremely far from the average or normal rage are more likely to reflect poor data. Some authors also suggest that highly skewed data could be levelled through logarithmic transformations and the data can be truncated if there are extreme outliers (Freudenberg, 2003; Nardo et al., 2008).
Different normalisation techniques will yield different results and robustness tests are needed to assess the results. Nardo et al. (2005) are highlighting following problems of the normalization procedure: loss of the interval level of the information, sensitivity to outliers, arbitrary choice of categorical scores and sensitivity to weighting.

3.2.6 Correcting problems with the data

Previous sections were concentrated on exploring the data before analysis and using different statistical tools. During the exploration of the data few problems could arise that will influence the results of further research.
Most of the statistical instruments are based on assumption of normality and homogeneity and it is known that variance-covariance matrix are sensitive to outliers in the data (Serneels and Verdonck, 2009). If outliers are detected there are several options for reducing the impact of these values (Field, 2009):

- remove the case, could be used only if there is a reason to believe that the data is not representing the region which is been sampled
- transform the data, as a transformation can reduce skewness of the data
- change the score, there are several options to do it – the next highest score plus one, convert back from z-score, the mean plus two standard deviations.

Table 3.3 Data transformation and their uses

Data transformation	Can correct for
Log transformation	Positive skew, unequal variances
Square root transformation	Positive skew, unequal variances
Reciprocal transformation	Positive skew, unequal variances
Reverse score transformation	Negative skew

Source: Field, 2009
Data transformation is an option when data does not follow normal distribution, but other non-parametrical tests should be considered at first, because data transformation leads to loss of important information (Field, 2009).

3.2.6 Weighting indicators

Since sustainability is a 'social construction', to determine the overall sustainability function, it is convenient to consider society's preferences to assign different importance to each dimension/indicator included in the composite indicator. Weighting is a very important step in the process of composite indicator creation, and it has a high impact in quality of the results and a sensitivity analysis is advised, with the aim of determining the extent to which weights influence results (Becker et al., 2017; Gómez-limón and Sanchez-fernandez, 2010).
There are three approaches that have been used for weighing: statistical, normative or hybrid, which combine statistical and normative (Decancq and Lugo, 2012). Statistical approach include principal component analysis, correlation and regression coefficient, the main problem is that the weights are based on the particular dataset, making comparison over time difficult (Santos and Santos, 2014). Normative approach is based on explicit value judgements (Santos and Santos, 2014). Sometimes for the creation of composite indicators several methods are used, for example expert´s

weightings are compared with factor analysis (Landaluce-Calvo and Gozalo-Delgado, 2021; Panda et al., 2016).
The equal weighting is the easiest technique, when all the indicators considered to have equal importance, the main advantage of the equal weighting is its simplicity, but usually it is used for composite indicators with fewer sub-indicators, for example HDI. Because composite that is created by the combination of more indicators will have a stronger influence on the list of composite indicators (Talukder et al., 2017). Nevertheless, equal weighting is the most common scheme appearing in the development of composite indicators (Bandura, 2011; Beccari, 2016; Nardo et al., 2008).
Statistical approach to derive weights is based on factor analysis, in this case weights are based on contribution of the indicator to the overall variance of the data (Landaluce-Calvo and Gozalo-Delgado, 2021; Nicoletti et al., 2000). Factor analysis reveals, within each regulatory topic the groups of related indicators, which are most associated with different underlying factors. Within these factors the sub-indicators are weighted according to the proportion of their cross-country variance, which is explained by the factor (Granco et al., 2019; Nicoletti et al., 2000). The factor is identifying groups of indicators, which usually can be economically interpreted. Afterwards countries or regions are ranked according to the factors using estimated weights. Factor analysis is appealing, because of its data-based nature, and the resulting composite indicator accounts for the large part of the cross-country variance of the detailed indicators. In addition, the composite indicator is not dependent on experts' opinions, and it concentrates on the dimensions which are important for differences between regions. To the disadvantages of data-driven approach count the sensitivity to modification in the basic data. Data updates and revisions are very likely to change the sets of weights. Also analysis is sensitive to outliers, and during the robustness analysis outlier regions should be identified and excluded (Becker et al., 2017; Lemke and Bastini, 2020).
Budget allocation technique needs a wide spectrum of experts with relevant knowledge and experience. Each of the experts gets a budget of points and should divide it among indicators according to the weights they should have in the composite indicator (Lafuente et al., 2020). The main problem of this method is the right selection of experts (Hudrliková, 2013). Another similar method is the public opinion method, but instead of experts there is a pool of people, which make the weighting process even more complicated (Chabova, 2017; Hudrliková, 2013; Koronakos et al., 2020).
Conjoint analysis is based on the interviews, in which respondents are asked how much importance they give to an individual indicator, i.e. their "willingness to pay" (Hudrliková, 2013).
The analytic hierarchy process (AHP) is based on using pairwise comparisons, it encompasses both qualitative and quantitative techniques into evaluation process (Saaty, 1990).
According to Graymore et al. (2009) to obtain accurate result the interactions between indicators and the impact they have on sustainability should be investigate using correlations and pairwise comparisons to help produce an integrated sustainability assessment.
There is no general consensus on using one of weighting scheme (Ebert and Welsch, 2004; Hudrliková, 2013; Nardo et al., 2008). Most of the composite indicators rely on equal weighting when all variables are given the same weight. The main advantage of equal weighting is its simplicity and transparency (Hudrliková, 2013). Nevertheless, Nardo et al. (2008) admits that equal weights are usually used when there is no clear idea what else could be used.
According to Saisana (2011) other weighting methods could be used when there are few indicators (between 3 and 10) and bivariate correlations less than 0,50. The correlation between indicators is setting the significance of the weights (Hudrliková, 2013).
Weights could be also an indicator of the statistical quality of the data. Data that are more reliable could be assigned with higher weights (Nardo et al., 2008).
Graymore et al. (2009) offer to use analytical hierarchy process to determine indicators weighting by pairwise comparisons of the indicators impact ratings. With help of pairwise comparisons, it

could be found out which indicator contribute to the assessment more than 5 %, so that a comprehensive composite indicator could be created.

Table 3.4 Advantages and disadvantages of different weighting methods

Advantages	Disadvantages
Benefit of the doubt – HDI, Sustainable development, social inclusion	
Indicator is sensible to national policy priorities because the weights are determined by the observed performances. The benchmark is based on linear combination of observed best performances. No problem of "unfair" weighting. Index is "incentive generating" rather than "punishing". Weights may help to define trade-offs and to overcome difficulties of linear aggregation.	Weights are country specific; no comparison is possible. Different normalization of the score will yield different weighting schemes. There is a risk of substitution of open experts` opinion with analyst´s manipulation of weights. Benchmark performance does not guarantee relative success of a country.
Unobserved components – governance indicator (Kaufmann et al., 1999)	
Weights do not depend on ad hoc restrictions. It can be used even if component indicators are not correlated.	Reliability and robustness depend on the quality and availability of data. With highly correlated sub-indicators there could be identification problems. If each country has a different number of sub-indicators, then the weights are country specific.
Budget allocation	
Weighting is based on expert opinion, Expert opinion could be an incentive for policy discussion and action.	Weights could reflect only specific local conditions. Allocation of a certain budget to too large numbers of indicators can give serious cognitive stress to the experts and could lead to inconsistent results. The weighting could reflect not the importance of indicator, but the urgency of political action in certain area.
Public opinion	
Deals with issues, which are important for public. Allows all stakeholders to express their preference and creates consensus for policy action.	Implies the measurement of "concern". This method could be inconsistent when dealing with high number of indicators.

Table 3.4 Advantages and disadvantages of different weighting methods (continued)

Advantages	Disadvantages
Analytic hierarchy process	
It could be used for qualitative and quantitative data. Relatively high transparency.	Connected to high costs, because a high number of pairwise comparisons are needed. The results depend on the evaluators and the setting of experiment.
Conjoint analysis	
Weights represents trade-offs between indicators. It considers socio-political context and the values of respondents.	It needs a specified utility function, and it implies compensability. Depends on the sample of respondents chosen and on how questions are formulated. Requires large sample of respondents. The estimation process is complex.

Source: Nardo *et al.*, 2008

Weighting with help of statistical models, usually it is principal component analysis or factor analysis, group together sub-indicators which are collinear to form a composite indicator that capture as much common information as possible (Mauro et al., 2018; Nardo et al., 2008). There are an important limitation of PCA/FA – it cannot be used when there is no correlation between the sub-indicators.

Data envelopment analysis (DEA) uses linear programming tools to assess an efficiency frontier that would be used as a benchmark to measure relative performance of countries. To do it a benchmark should be constructed and distance between countries in a multi-dimensional framework. Usually benchmark is set by hypothetical decision-maker, it is similar to budget allocation method where experts are asked to assign weights to sub-indicators (Nardo et al., 2008; Zhou et al., 2018). The application of DEA is known as benefit of the doubt approach.

Another method is unobserved components model (UCM). In this method, sub-indicators are assumed to depend on an unobserved variable plus an error term. This method resembles regression analyses, the main difference is in the dependent variable which is unknown (Charles et al., 2017; Karagiannis, 2017; Nardo et al., 2008).

Conjoint analysis is a qualitative technique, which is based on "willingness to pay" valuations. Respondents should define how much value they attach to sub-indicator. Although this method is using statistical instruments, it is still based on value judgments (Nardo et al., 2008).

In the table 3.4 the advantages and disadvantages of the methods are presented.

In the literature a number of methods have been used to derive weights and different results can be obtained (Wang, 2015). They include analytic hierarchy process method (Gómez-Limón et al., 2020; Kurka, 2013), PCA method (Gómez-Limón and Riesgo, 2009; Vyas and Kumaranayake, 2006), grey relation analysis (Lee and Lin, 2011) and Delphi method (Galo et al., 2014; Tang et al., 2014). One common feature of these approaches is that it needs comparison among sub-indicators, which makes the approaches frequently criticized (Wang, 2015).

As there are several techniques for definition of indicators weights the most preferable are methodologies, which are data based, and are less value loaded. Nevertheless, the fact, that statistical instruments are used; the weighting procedure is a value judgement.

During multivariate analysis when the data was suitable for PCA the components and factor loading will be identified. Nicoletti et al. (2000) is offering, to weight each indicator according to the proportion of its variance that is explained by the factor it is associated to (the normalized squared loading), while each factor is weighted according to its contribution to the portion of the explained variance in the dataset (the normalized sum of squared loadings).

In Russian scientific literature some examples of attempts for constructing composite indexes could be found, but the weighting part is often contradictory and lack transparency (Novikova and Krasnikov, 2009).

3.2.7 Aggregation of indicators

After assignment of weight the question arise how to aggregate the underlying indicators. Mathematical aggregation methods also vary; they could be linear or geometric. Linear aggregation is possible when sub-indicators have the same measurement unit. Geometric aggregations are better suited for the non-comparable sub-indicators, which are expressed in different ratio-scales (Karagiannis, 2017; Nardo et al., 2005; Talukder et al., 2017).

Assuming that there are m regions, whose composite score is to be constructed based on q indicators (Saltelli et al., 2008). All indicators have been converted into benefit-type ones, so that the higher value corresponds to better performance. The aggregation method of weighted arithmetic mean can be expressed by following equation:

$$\mathrm{CI}_j = \sum_{i=1}^{q} w_i X_{ij} \qquad (9)$$

Where X_{ij} and w_i respectively are the value for a region j with respect to indicator i and weight assigned to indicator i (Saltelli et al., 2008). This type of aggregation is popular due to its transparency and ease of interpretation. According to Ebert and Welsch (2004) the indices in the form of an arithmetic mean are mostly not meaningful because the variables do not satisfy the required property of interval-scale unit comparability.

There are several additive aggregation methods. The simplest method entails the calculation of the ranking of each country to each sub-indicator and summation of the resulting ranking. This method is based on ordinal information, it is simple and independent of outliers, but the absolute value of information is lost (Nardo et al., 2008; Talukder et al., 2017).

Another method is based on the number of indicators that are above and below some benchmark. This method uses nominal scores for each indicator to calculate difference between the number of indicators that are above and below a threshold. This method is also simple and it is not affected by outliers, but the interval level information is lost (Nardo et al., 2008).

The most widespread linear aggregation method is the summation of weighted and normalised sub-indicators. For this method, the problem lies in data quality and the unification of unit of measurement of underlying indicators. In addition, additive aggregation could result in a biased composite indicator when there are synergies or conflicts between sub-indicators.

An alternative aggregation method is the weighted geometric mean:

$$CI_j = \prod_{i=1}^{q} X_i^{w_i} \qquad (10)$$

For environmental variables the methods with geometric mean preferred to be used (Ebert and Welsch, 2004).

Although there exist a wide variety of functional forms that permit indicators to be aggregated, it is worth taking into account the possible incommensurability of different indicators or dimensions of sustainability (Asadzadeh et al., 2017; El-Zein and Tonmoy, 2017; Gómez-limón and Sanchez-fernandez, 2010). This circumstance depends on the concept of 'sustainability' being considered: 'weak' sustainability vs. 'strong' sustainability (Hedinger, 1999). Saltelli et al. (2008) also admit that compensability among indicators is argument in favour of a geometric approach. In case of arithmetic aggregation poor performance in some indicators can be compensated by sufficiently high values of other indicators (Nardo et al., 2008; Saltelli et al., 2008).

As a common practice, greater weight could be given to components, which are considered more significant in the context of the composite indicator. In addition, weights in additive aggregations have the meaning of substitution rates (trade-offs), which leads to theoretical inconsistency in the way weights are used and their theoretical meaning. Non-compensatory multicriteria approach is dealing with this problem (Nardo et al., 2008). Thus, non-compensatory aggregation should be used to interpret the weights as "importance coefficient" (Becker et al., 2017; Podinovskii, 1994).

Non-compensatory logic is considering the absence of preferential independence within a discrete non-compensatory approach. During the mathematical aggregation, convention can be divided into two main steps:

- Pair-wise comparison of countries according to the whole indicators set
- Ranking of countries in a complete pre-order.

There are several ranking methodologies one possible algorithm is the Condorcet-Kemeny-Young-Levenglick (CKYL) ranking procedure. According to this algorithm the ranking of countries with the highest likelihood is the one supported by the maximum number of sub-indicators for each pair-wise comparison, summed over all pairs of countries considered (Haak and Pagilla, 2020; Nardo et al., 2008). This method can overcome some of the problems of additive or multiplicative aggregations. Moreover, qualitative, and quantitative information can be jointly treated, also it does not need any normalization to assure comparability of results. For this method the weights definition is of crucial importance, as it has the most influence on the results (Nardo et al., 2008).
As was already mentioned, the main problem of additive aggregation is its compensability, as lower value of one indicator can be compensated by high value of another indicator. Additive linear function assume total compensation among indicators, geometric and multiplicative functions permit partial compensation (Gómez-limón and Sanchez-fernandez, 2010). When the analysis entails full non-compensability then multicriteria functions should be used to prevent any type of compensation. Also for non-comparable data, only geometric aggregation could yield consistent results (Nardo et al., 2008; Talukder et al., 2017).
Several methods of aggregation are available and it is a source of the criticism of composite indicators – the subjectivity of methodology choice (Böhringer and Jochem, 2007; Ebert and Welsch, 2004; Gómez-limón and Sanchez-fernandez, 2010; Hueting and Reijnders, 2004; Morse, 2008).

3.2.8 Robustness and sensitivity.

The process of composite indicator construction involves many subjective judgments, even when only statistical procedures are used. The choice of a certain procedure still will be subjective. That is why to limit misleading and non-robust indicators quality of composite should be checked with sensitivity analysis (De Montis et al., 2020; Nardo et al., 2008; Talukder et al., 2018).
The sensitivity analysis is an "*x-ray*" of model, which studies the relationships between information coming in and out of the model. The sensitivity analysis should assess how the given indicator depends upon the information fed into it during the construction of the composite. Sensitivity analysis is closely linked to uncertainty analysis, which is quantifying the overall uncertainty in the ranking as a result of the uncertainties in the model input (Charles et al., 2017; Nardo et al., 2008; Saisana and Saltelli, 2008).
The aim of the combination of these two analyses is to increase transparency, to identify which countries are favoured or deteriorate under certain assumptions and to help framing a debate around the index (Kuc-Czarnecka et al., 2020; Nardo et al., 2008).
Every step of composite indicator composition can lead to uncertainties and to inconsistent result. During composite indicator construction researcher is making many different decisions: which indicator to include into the composite, which method, or model to use for imputation of missing data, for normalization, weighting, or aggregation. The choice of unsuitable method could lead to misleading result (Becker et al., 2017; Nardo et al., 2008; Saisana and Saltelli, 2008).
Sensitivity analysis is used to show the validity of results of the numerical model simulations (Diukanova, 2018; Hermeling and Mennel, 2008).
There are stochastic and deterministic approaches to the sensitivity analysis (Hermeling and Mennel, 2008). Deterministic approach assumes that the basic economic parameter stems from a known interval and quantifies the spread of the corresponding equilibrium output variables, it can be numerically implemented by piecemeal formulae. Stochastic approach treats the parameter as a stochastic variable with known distribution and calculates mean and variance of output variables

accordingly, it is implemented by a Monte-Carlo or a Gauss-Quadrature algorithm (Hermeling et al., 2013; Hermeling and Mennel, 2008).
Nardo et al. (2005) offer to conduct the analysis in a single Monte Carlo experiment – all uncertainty sources should be eliminated simultaneously to capture synergy effects among uncertain input factors. Every uncertainty assumption gets a discrete uncertain factor. The output of uncertainty analysis is the rank of given countries (the rank is changing with different methods) and the relative shift of the absolute differences in countries´ rank with respect to a reference ranking (Nardo et al., 2008).
Following step should be taken during uncertainty analysis:

- Assign an input factor for every procedure which can bring uncertainty
- Generate randomly combination of independent input factors
- Close the loop over a set of input factor and analyse the resulting output vector (Nardo et al., 2008).

The result of robustness analysis is usually reported as country rankings with their relative uncertainty bounds.
The sensitivity analysis measures how much uncertainty in the composite indicator for a country would be reduced if that input source of uncertainty were removed. According to Nardo et al. (2005) the sensitivity analysis in case of composite indicators could be applied to two model outputs difference in country score and rank shift. To analyse the effect of an uncertainty factor X_i on composite indicator a so-called sensitivity measure is used, it is defined as the fractional contribution to the model output variance that derives from the uncertainty in X_i.
Composite indices also need to be validated, the aim of validation is not to determine if the indicator is measuring the sustainability in the right way, but to check how volatile and robust the indicator is with respect to changes in the methodological assumptions within a plausible and legitimate range (Saisana and Saltelli, 2008).
Beccarri (2016) has undertaken an extensive search of scientific and grey literate on the composite indicators, and he has stated that only 19 % of the methodologies employed any sensitivity or uncertainty analysis and it significantly limits the quality and reliability of the existing methodologies.
In the table 3.5 a summary on several composite indicators of sustainable development, published in the scientific literature in last years, are presented. The most of these indicators are using the OECD procedure for creation of composite index. The frameworks for the creation of the composite are usually based on different theoretical foundations, which are adopted to the assessed region, the adoption is sometimes forced (for example in case of missing data) or voluntary (based on correlation analysis).
Equal weighting is also often used as well as PCA and AHP. Additive aggregation is the most popular procedure in the presented indicators. Sensitivity analysis is often neglected, or not mentioned in the research article.

Table 3.5 Overview of the existing composite indicators for sustainability assessment

	Theoretical framework	Normalisation	Weighting	Aggregation	Sensitivity Robustness
Composite indicator for the islands of the North Aegean region, Greece (Kondyli, 2010)	Tailored to the regional specifics three-dimensional framework: economic, social, and environmental	Min-Max	Equal	Arithmetic mean	+
composite index of sustainable development for Italian regions (Salvati and Carlucci, 2014)	99 variables relevant to different research domains based on the framework presented in (Ronchi et al., 2002)	Z score Min-Max	Equal PCA	Arithmetic mean	+
Composite index for the assessment of social sustainability in India (Panda et al., 2016)	A mixture of indicators from different scientific sources (MDGs, Global city indicators, Human development reports and others)	Min-Max	Expert AHP	Arithmetic mean	-
SDG index (Lafortune et al., 2018)	In 2018 edition 109 indicators (SDGs targets and OECD indicators)	Min-Max	Equal	Arithmetic mean	+
An integrated indicator system and evaluation model for regional sustainable development (Shi et al., 2019)	Framework based on (Phillis et al., 2017; Popović, 2019; Tran, 2016), corrected with discrimination analysis, Pearson correlation analysis and partial correlation.	Min-Max	AHP	Arithmetic mean	-
Composite Measure of Regional SD in Indonesia (Rahma et al., 2019)	6 performance indicators: Economic growth rate, unemployment rate, poverty rate, HDI, Gini index, environmental quality index	Min-Max	Shannon entropy	Geometric mean	+
Composite Indicator to Measure Environmental Sustainability (Gómez-Limón et al., 2020)	SAFE (Sustainability Assessment of Farming and the Environment) (Van Cauwenbergh et al., 2007)	Min-Max	Expert AHP	Arithmetic geometric mean	-

3.2.9 Links to other variables and decomposition

Composite indicators could be linked to other well-known measures, which also assess the phenomena. The links could be presented with cross-plots to illustrate these links. For example, comparison of poverty index to GDP could help to make a conclusion how the economic development of a region or a country is influencing the poverty reduction. In addition, high correlation of composite index with well-known indicators, which are measuring the phenomena, suggests high quality of the composite. As correlation indicates, that the variation in the two data set is similar (Becker et al., 2017; Nardo et al., 2008).

Composite indicator is the starting point of analysis, as they serve an aim to become a signal for policymakers for political action. After creation of composite indicator, the data could be decomposed so that the contribution of the sub-components could be identified (Nardo et al., 2008). To profile the country or region performance the individual indicators could be used to demonstrate strengths and weaknesses (Nardo et al., 2008; Talukder et al., 2018). It could be done in several ways:

- Leader and laggards – performance of certain indicator is compared to the leader, the laggard and average performance
- Spider diagrams – performance is compared to the several best countries
- Traffic light presentations – each indicator gets green, yellow, or red colour according to the performance.

The result of this step is a chosen signal system demonstrating strengths and weaknesses of a region.

3.2.10 Presentation and dissemination

The main purpose of composite indicator is to communicate the trends of development to policymakers, and the way in which these results are presented is an important issue. Composite indicator should illustrate information accurately and quickly. There are interesting ways to display and visualize composite indicators (Nardo et al., 2008):

- Tabular format – each indicator is presented as table of values, it is a comprehensive approach, but it could be too detailed and not visually appealing
- Bar chart – with countries on vertical axis and the values of composite on horizontal axis. Also, average performance could be added
- Line charts – are used for comparison of performance over time and allow comparison over countries
- Trend diagrams – are suitable for presenting trends.

The result of this step is a visual presentation of the analysis.

3.2.11 Setting the reference value or baseline

After creating, a composite indicator important step is to compare it to a reference value. This comparison gives the indicator meaning and distinguishes it from raw data (Gallopin, 1997). The simplest reference point is the baseline (Moldan et al., 2012). Baseline are starting points for measuring change from a certain state or date (en Brink, 2007). Baselines are commonly used in different fields as medicine, economics, management etc. Important is that baseline is not a target itself, the target is set by policy-maker (Moldan et al., 2012).

Reference value or baseline could be used as background value, standard or norm, or it can be a threshold value for something like irreversibility or instability of a system (Rickard et al., 2007). There several examples of sustainability reference values in the literature: sustainable yield, carrying capacity, critical load or minimum viable population (Moldan et al., 2012).

Reference value is an important part of the assessment, but its use also brings certain debates. The choice of targets and reference values is normative and politically challenging, nevertheless even rough targets could become an important policy driver stimulating both research and policy debate (Moldan et al., 2012).
Each phase of composite indicator building process is important and should be carried out with clear aims in mind (Nardo et al., 2008). For example, sound theoretical framework should ensure the relevance of selected sub-indicators; the multivariate analysis is important to increase its reliability; the imputation of missing value and normalisation can affect its accuracy (Becker et al., 2017; Nardo et al., 2008).

3.3 Research design for sustainability assessment

The first step of assessment was the selection of theoretical framework. After analysis of available sustainability assessment indicators set, as a base for assessment the UNCSD framework was chosen for ex-post analysis of the development in Tambov region, as the statistical data for the sustainability development goals was not available. Also, some customization of the indicator set was unavoidable due to data collection limits, for the analysis the data provided by the federal state statistical service was used.
The next step was the selection of variables. Result of this step were summary tables on data characteristic availability (across country, time), sources, possible substitute in case it was not available. On the base of availability and relevancy characteristics, the decision was made which indicators should be in the final set and which indicators should be substituted or eliminated.
With the help of local experts, the UNCSD set of indicators was customized to the local characteristics. Also, the question if this set could be used as a signal system for the problems that could threaten sustainability of a region. On one hand, the set of indicators should be assessed from the point of different dimensions: “How well the economic, ecologic, and social dimensions are covered?” On another hand, the interaction between the dimensions should also be dealt with. Maybe to the set of indicators another important indicator should be added, but this question should be addressed also from the perspective of data availability.
The next block of research was devoted to the work with selected indicators. At first multivariate analysis was performed to analyse the structure of the data, and the result of it were extracted factors and components, which were explaining the overall phenomenon. During multivariate analysis the correlations between selected base indicators were checked to avoid double counting, and similar groups of sub-indicators were identified to simplify the interpretation of results (Gómez-limón and Sanchez-fernandez, 2010).
In case of missing data, the techniques for data imputations could be used. It is not relevant for the current research, as the choice of variables is highly influenced by the data availability and the sub-indicators with missing data were excluded from the analysis at the phase of data selection.
The next step of the composite indicator creation was normalisation, for the research following normalization techniques were compared:

- z-scores with zero means and unit variance
- re-scaling or min-max standardization
- distance to a reference.

Ordinal response scale and distance to the mean are not included in the research because during the normalization large amount of information is getting lost and the over-time improvement is hardly traceable (Nardo et al., 2008).
During the research the data from 2012-2016 was used, 2012 is taken as a base or reference year. For the research the data from federal state statistical service was used.
Apart of analysis of local statistical data 10 interviews with local experts were performed.

The interview was semi-structured with open questions. The first part was devoted to the clarification of the sustainability understanding and perception, and in the second part the experts were asked to set the weights for indicators.
During the interview the expert was provided with a list of all sub-indicators and were asked to set a rank for each indicator. Expert could choose from three possibilities: very important, important, not important. Besides the importance of the indicators – the opinions were gathered which indicators are not relevant for the regions.
After variables are selected and normalized and before it can be aggregated, the weights should be set for each sub-indicator. For the research following weighting techniques were compared:

- equal weights
- weights extracted with help of PCA
- weights based on the expert interviews.

Table 3.6. Overview of the used techniques.

Step	Method	Result
Theoretical framework	Literature analysis, experts' interview	Clear documentation of selected framework and structure of researched phenomenon
Selection of variables	UNCSD framework vs. data availability	Summary table on data availability
Regional analysis	Comparison of UNCSD indicators on the regional and average Russian level	Regional analysis Sustainability polygons
Multivariate analysis	PCA, factor analysis	Interpretation of the multivariate analysis, components, and factors
Imputation of missing data	Not relevant	Explanation of selected imputation techniques and results
Normalization	Z-scores, standard deviation from the mean, distance from the leader; distance from the worst performer; distance from the mean.	Explanation of selected normalization techniques and results
Weighting and aggregation	PCA, equal weighting, expert weights Additive aggregation	Explanation of selected weighting procedure and results
Robustness and sensitivity	Monte Carlo simulation Sensitivity measure	Explanation of results of sensitivity analysis
Links to other variables		Explanation of correlations and results
Decomposition	Spider diagram; leaders and laggards	Explanation of the drivers of aggregated results
Presentation	Graphic tools	Visualization of the results of the composite indicator

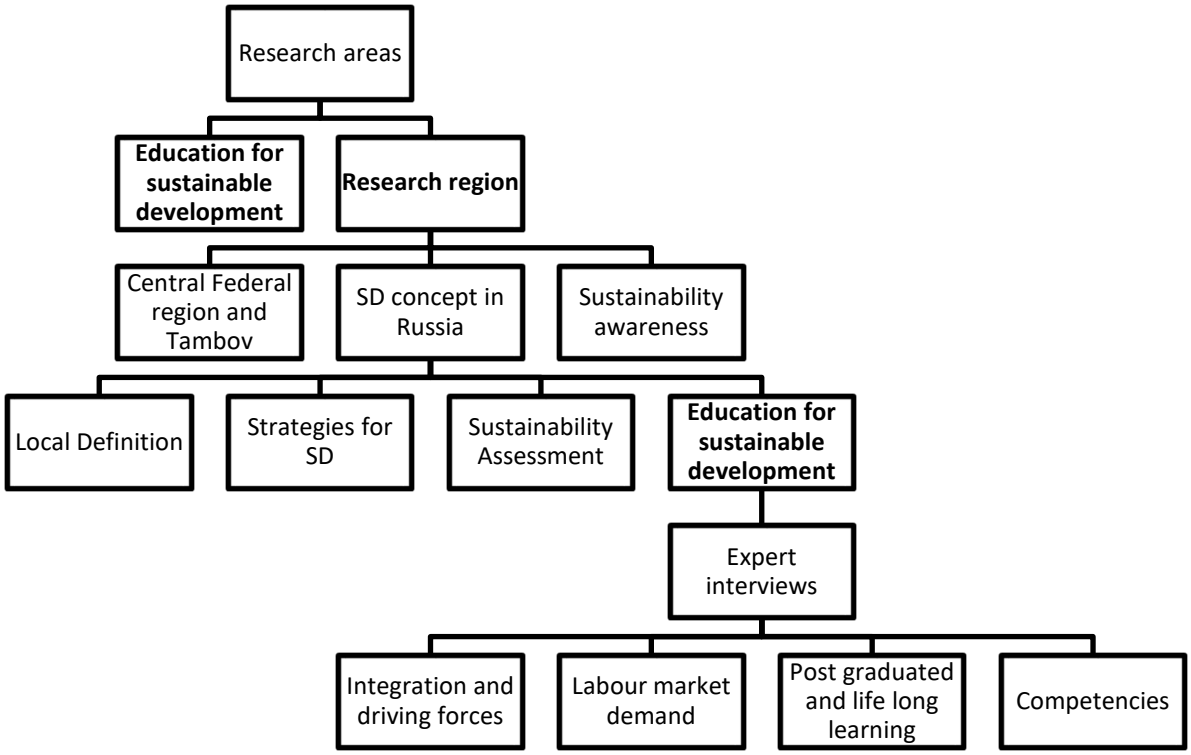
Source: own elaboration

For the expert's weight 10 interviews were performed in Tambov region. Out of 10 experts, six were the representatives of local administrations with responsibilities for rural development; remaining four were the representatives of regional ministries.
The next step was devoted to the check of robustness of the indicators, and the sensitivity analysis, which should answer the question: "How is the composite indicator and consequently the rank of the region is influenced by the different methods of normalization or weighting of the sub-indicators?". The result of this step was a diagram with confidence interval which was showing how the rank of the region is influenced if different methods of indicator composition is used.
The next block was devoted to the presentation and explanation of the results. To get a better understanding of the reasons of the phenomenon one step back should be taken – composite indicators should be decomposed to find out the driving forces of aggregate indicator.
With this data collected for these indexes it was possible to perform SWOT analysis of the region with an aim to find out possible potentials and threads for the future policy decisions.

3.4 Education for sustainable development

The second part of the research has an aim of investigating the educational response to global sustainability concerns through the perspective of university staff in Russia involved in Education for Sustainable development. To get an overview of the place of sustainability in Russian education there is a need for qualitative methodologies, as such data could only be gathered through interviewing.

Fig. 3.1 Linkage of the chapter to the overall structure of the thesis



Source: own illustration
There are several topics which should be discussed with the experts, as result recommendations for possible measure should be offered.

3.5 Qualitative research

There are different techniques for analysing data and when a research problem has been identified the researcher must select a suitable tool or method. Most of the tools are divided into two groups

quantitative and qualitative research techniques. Qualitative research is unlike quantitative research is measuring data not in terms of frequency or quantity but rather in terms of in-depth meanings and processes (Labuschagne, 2003). Nevertheless, the fact that these two types of research are using different tool Labuschagne (2003) underlines that these two approaches should be regarded as complementary rather than competitive.
Miles et al. (1994) are highlighting the strengths of qualitative data, one major feature is that the data focus on *naturally occurring, ordinary events in natural setting*, and the possibility for understanding latent, underlying, or nonobvious issues is strong.
Another strength of qualitative data is their richness and holism, with strong potential to reveal complexity (Miles et al., 1994). Qualitative data with emphasis on people´s experience are well suited for locating the meaning people place on events, processes and structure of their lives and for connecting these meanings to the social world around them (Miles et al., 1994; van Manen, 1977).
Qualitative methods consist of three kinds of data collection (Labuschagne, 2003):

- In-dept, open-ended interviews
- Direct observation
- Written documents, including such sources as open-ended written items on questionnaires and personal diaries.

Table 3.7 Types of visual displays and purposes

Visual display	Purpose
Boxed display	To highlight a specific narrative considered important and frame it in a box
Decision tree modelling	To describe options, decisions, and actions
Flow chart	To illustrate directional flow and show pathways of different groups
Ladder	To represent the dimensions of the progression of certain phenomenon through time or to show levels or stages
Matrix	To cross two or more dimensions, variables, or concepts of relevance to the topic of interest
Metaphorical visual display	To depict in a metaphorical way the topics or themes found
Modified Venn diagram	To indicate shared or overlapping aspects of a concept, a category, or a process
Network	To depict relationships between themes and subthemes or categories and subcategories
Taxonomy	To classify or organize information

Source: (Verdinelli and Scagnoli, 2013)
From open-ended interview a researcher could analyse direct quotations of people about their experience, opinions, feelings, and knowledge. From observations a researcher could gain detailed descriptions of participant´s behaviour and human interactions. Documents analysis yields excerpts, quotations, or entire passages from records, correspondence and open-ended surveys (Labuschagne, 2003).
The centre of qualitative research is the understanding of the meaning of the phenomena and the lived experience with an emphasis on the participants points of view on a certain issue

(Labuschagne, 2003). Qualitative research gives an opportunity to constitute compelling arguments about how things work in particular contexts (Mason, 2002).
According to Miles et al. (1994) analysis of quantitative data consists of three concurrent flows of activity: data reduction, data display, and conclusion drawing/verification.
Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data collected during interviews (Miles et al., 1994). Data reduction starts from the moment as a researcher chooses which conceptual framework to use, which research question to pose. As data collection proceeds, further data reduction episodes occur – coding of information, paraphrasing, grouping results (Miles et al., 1994).
Data display is an organized, compressed assembly of information that permits conclusion drawing and action (Miles et al., 1994). Data display in a graphic format is a way of presenting information succinctly and efficiently (Verdinelli and Scagnoli, 2013). It is supposed to provide a multidimensional space to organize data and show connections between different pieces of relevant data (Dey, 1993).
There are several ways to display data in the table 3.7 the types and purpose of different displays are presented (Verdinelli and Scagnoli, 2013).
The third stream of the analysis activity is the conclusion drawing and verification. The conclusion drawing is an on-going process which is happening during every stage of research, but it is often that final conclusions may not appear until data collection is over (Miles et al., 1994).

3.5.1 Questionnaire and interviewing

Expert interview is a widely used technique in data collection for different researches , but it is also popular to rely on observational data (Beyers et al., 2014). The major advantage of observational data is that subjects of research interest cannot react to or distort the research process. However, while observational data are appropriate for many research questions, there are some questions which are difficult to assess with only observational data. For example, when a restricted amount of evidence is publicly available, or public sources are limited, incomplete or unreliable (Beyers et al., 2014).
What kind of data can be collected through interviewing? Interviews are important for capturing internal interactions and processes (Beyers et al., 2014). For example, it is difficult to get information about how the concept of sustainability is communicated to the people implementing different measures or how the actors are understanding the offered policy proposals, the only way is to interview the stakeholders, who are involved in those processes.
From the other side expert could be biased or could misinterpret different phenomena, Beyers et al. (2014) offers following methods to lower the bias in expert interviews:

- Carrying out multiple interviews for the more complicated cases
- Using secondary sources to cross-validate the interview responses
- Establishing good prior knowledge about each specific case before conducting the interview.

According to Sandelowski & Barroso (2007) one-to-one interviews are the most used data collection tools in qualitative research. Sampling in qualitative research designs often draws from small and purposive, rather than large and random, samples of people for in-depth and contextual investigation (Carter and Dresner, 2001; Kuzel, 1999). Semi-structured interviews are commonly recommended for collecting data from experts (Carter and Dresner, 2001; Flick, 2006; Miles et al., 1994).
During the formulation of the interview questions following rules should be noticed (Lienert and Raatz, 1998):

- Avoiding ambiguous terms
- Query only one factual content per question
- Using expressions that are part of the vocabulary of all respondents
- Using positive wording

- Avoiding double negations and generalizations
- Avoiding excessive length and compulsory brevity of the formulations.

The number of experts needed for interview is usually defined by theoretical saturation, saturation is defined as a scenario when no new information is emerging through the data collection and coding processes (Glaser and Strauss, 1967).

Miles et al. (1994) is offering following procedure for the analysis of interviews:

1. Identification of codes „meaning units" from the participants´ answers
2. Sorting of the meaning unit codes and placing them in their emergent categories, search for themes or patterns
3. Examination of categories for meaning and interpretation
4. Visual representation of the themes found in the data.

Schmidt (2004) is also offering to add another step to this analysis and to start with setting up the categories based on literature search. The guiding principle in the analytical strategy is the interchange between material and theoretical prior knowledge (Schmidt, 2004). During the interchange process the theoretical pre-assumptions may also be refined, questioned, and altered.

During the coding and categorisation process it is important not to tailor the material to one´s own theoretical assumptions by reducing the analysis to a search for locations in the text that are suitable as a proof or illustration of the assumptions (Schmidt, 2004). That is why repeated reading of the texts is important to notice all parts of texts, not only well suited to the prior beliefs (Hopf, 2016).

The coding process can take different forms, it may be a matter of content topics and aspects, or it could relate to the linguistic form of the responses (Schmidt, 2004).

Coding process is a way to reduce the information and information loss is unavoidable, but this is correspondingly less the more differentiated the analytical categories and their content features can be in their formulation (Schmidt, 2004).

The next step of the analysis is to analyse the coded categories and look for interpretation, usually it involves the compilation of quantifying the results of coding (Schmidt, 2004). It could be presented in forms of tables with indication of frequencies in individual analytical categories. To contribute to transparency and verifiability it is sensible to presents the results in a form of a table where each case is presented in a single line, and each column gives the results of the individual analytical categories (Hopf, 2016; Schmidt, 2004).

The last step is the detailed case interpretation, the goals of this stage could be identification of new hypothesis or testing a hypothesis, distinguishing between conceptual terms or revision of existing theoretical frameworks (Schmidt, 2004).

3.5.2 Quality criteria of the research

Quality criteria in qualitative studies differ from the quantitative studies. According to Korstjens and Moser (2018) the best quality criteria were offered by Lincoln and Guba (1985). A description of these criteria is presented in table 3.8.

To ensure credibility a researcher should follow several strategies: prolonged engagement, persistent observation, triangulation and member check (Korstjens and Moser, 2018).

3.6 Research design for the assessment of the sustainability education

The aim of this part of the research is to answer following questions:

1. How is sustainability integrated into the higher education in Russian Federation?
2. How is the concept of sustainability interpreted? Which aspects of sustainability are covered in the education? Is the ecological aspect prevailing?
3. How is the concept of sustainability integrated into post-graduated education?
4. Are there any changes in the awareness of the students concerning sustainability issues?

There are several reasons why qualitative approach is suitable for this study:

1. Limited information is available about the sustainability issues in Russia

2. The participant sample is small
3. Questionnaire is designed to strive for a more subjective, interpretative position from the interviewees.

Table 3.8 Trustworthiness: definitions of quality criteria in qualitative research.

Criteria	Description
Credibility	The confidence that can be placed in the truth of the research findings. Credibility establishes whether the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views.
Transferability	The degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents. The researcher facilitates the transferability judgment by a potential user through thick description.
Dependability	The stability of findings over time. Dependability involves participants' evaluation of the findings, interpretation, and recommendations of the study such that all are supported by the data as received from participants of the study.
Confirmability	The degree to which the findings of the research study could be confirmed by other researchers. Confirmability is concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but clearly derived from the data.
Reflexivity	The process of critical self-reflection about oneself as researcher (own biases, preferences, preconceptions), and the research relationship (relationship to the respondent, and how the relationship affects participant's answers to questions)

Source: (Lincoln and Guba, 1985)

For investigating the theme of sustainability development in Russia 16 interviews with experts from 8 universities were conducted. An a priori list of potential experts was selected out of universities staff actively participating in projects for sustainable development. Experts from that list were asked to indicate other expert specialized on the theme of the study. This procedure entails data analysis after each interview and follows the basics of snowballing and gradual sampling techniques (Flick, 2006; Kuzel, 1999).

The number of interviewed experts were based on theoretical saturation (Glaser and Strauss, 1967). The interviews were semi-structured, and several scenarios were prepared in case the interviewed person had limited experience with sustainability issues, after interview questions were modified or complemented as relevant themes emerged. To ensure data quality member checks were carried out verbally throughout interviews by using paraphrases and summaries or clarification during and after the data collection dialogues (Shenton, 2004). The participation of respondents from several universities reduced bias that may stem from the specifics of an institution, from each university at least 2 staff members were interviewed. Triangulation with secondary literature was also conducted.

The specific purpose of this study was to understand the development stage of the education for sustainability, as it is quite often that official documents differ from how the measures are implemented. The interviews were aimed to gather information about how well the education for sustainability is developed now and what ways exist to make the education more effective.

In line with these concepts a combination of two sampling criteria was used in this study – an a priori determination and theoretical sampling (Flick, 2006; Glaser and Strauss, 1967; Merkens, 2004)

Table 3.9 Research design

Phase	Procedure
Questionnaire creation	- Literature research - Discussion of the questionnaire - Trial interviews
Data collection	- Personal interviews (N=16)
Data analysis	- Data transcription - MAXQDA content analysis - Visualisation
Conclusions	- Final assessment of the results

Source: own elaboration

In interviews it is especially interesting to distinguish between interviewee who are already working with sustainability programmes or are trying to facilitate the integration of sustainability into curriculum with interviewees who not actively involved in the integration of sustainability into education.

As a basis for questionnaire creation literature research was performed. The main aim of this research was to gain an overview of the official state of the integration of sustainability into the education. On the base of literature search several blocks of questions were formulated, following the rules offered by Lienert and Raatz (1998).

Before conducting the interviews, several pre-tests were performed to correct the formulation of the questions.

All interview data based on participants´ responses to each question were transcribed verbatim. Then coding categories were generated in line with the aims of the study. For the data analysis the MAXQDA, qualitative data analysis software, and descriptive analysis technique was used.

The interviews were analysed inductively using content analysis to identify unique and recurring themes (Glaser and Strauss, 1967). The results were triangulated by comparing it with the previous understanding developed through literature research.

The interviews were performed in July and August 2020, the duration of interviews was between 25 and 55 minutes.

There were two versions of questionnaires used for the experts from universities with on-going master program with major in sustainable rural development and for the experts from universities without study programs with sustainability majors. Nevertheless, both questionnaires were covering the same topics to provide a possibility for comparison.

The questionnaire was designed in accordance with research questions, the guiding line of the interview questions were to find out the state of integration of sustainability topics into education, the problems in understanding of the sustainability concept, possibilities for strengthening the sustainability awareness through education.

Expert´s interview cannot provide representativity in statistical sense, but it has an aim to reach content representativity and it could be gained if the interviewees are not just individual cases, but are regarded as representatives of their groups (Mayer, 2013). That is why expert´s choice play an important role, in the table 3.10 an overview of the experts is presented. The interviewees were representatives of universities with and without a master program in sustainable development, among experts were teachers as well as head of institutions.

Table 3.10 Overview of the interviews

Position at University	Universities with SD Master	Universities without SD Master	Total
Head of institution	4	2	6
Teacher	6	5	10
Total	9	7	16

Source: own elaboration

By using qualitative methods, it was possible to disclose features of the education for sustainability which are difficult to reveal with other methods. The presented empirical findings are not considered statistically significant but aim to shed light on the integration of sustainability topics into education of Russian agricultural universities and to help to elaborate possible recommendations for better integration.

Sustainability assessment of Tambov region

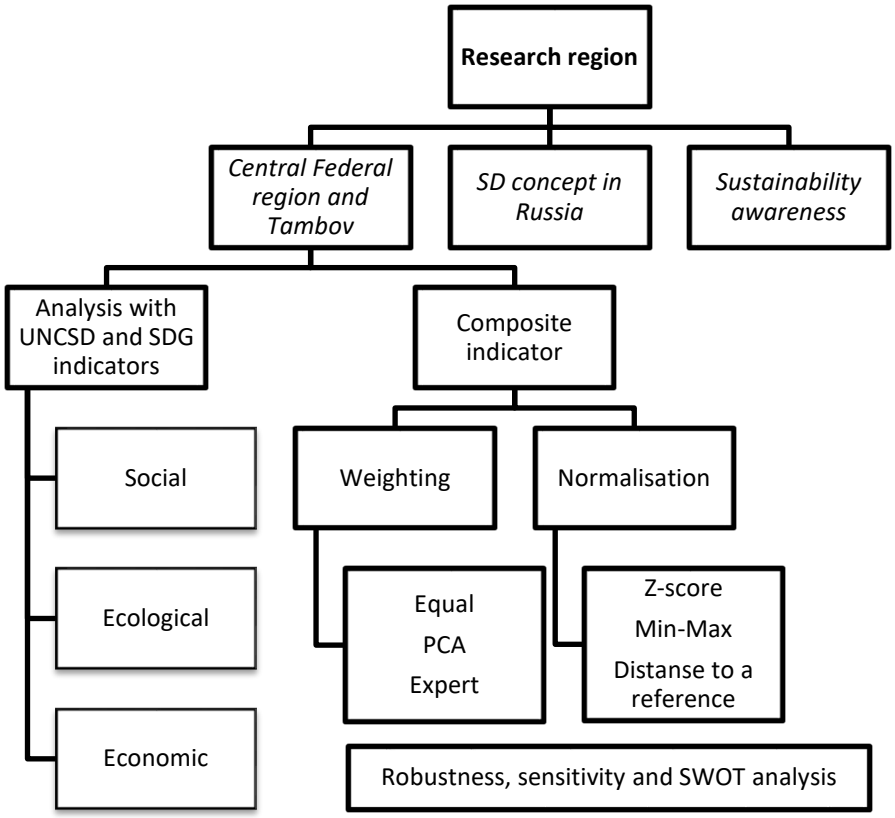
The UNCSD indicators set is serving an aim to assess current situation in the region, indicators simplify, clarify and aggregate the information and they help to communicate information to the decision-makers (Reed et al., 2006; United Nations Commission on Sustainable Development (UNCSD), 2007). It should help to perform SWOT analysis. The problem zones could be a limitation for future policy and at the same time the potential of spheres with high level of development could be used.

The set of indicators should be adapted to the national conditions, the criteria for the adjustment are usually:

- National strategies, targets, and priorities
- Existing indicators and indicator programmes
- Data availability (United Nations department of economics and social affairs, 2006).

In the next chapter the assessment of Tambov region will be presented, the assessment is following the UN CSD framework.

Fig. 4.1 Structure of the chapter



Source: own illustration

The assessment includes indicators for social, ecological, and economic sphere. At this step of the research, it is important to analyse the overall trend of regional development and to see which indicators are available for further analysis.

4.1 Social sustainability

4.1.1 Poverty

At the World Summit on Social Development in Copenhagen in 1995 absolute or extreme poverty was defined as: '... a condition characterised by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information' –

therefore, mainly depending on access to a range of services (United Nations, 1995).

Table 4.1 Summary table of data characteristics

Indicator	Availability		Source	Substitution
	Level	Period		
Proportion of population living below national poverty line	Regional	2000-2019	Rosstat	-
Proportion of population below $ 1 per day	Not available	Proportion of population living below national poverty line		
Ratio of share in national income of highest to lowest quintile	Regional	2000-2019	Rosstat	-
Proportion of population using an improved water source	Regional	2012-2019	Rosstat	-
Share of households without electricity or other modern energy services	Regional	2012-2019	Rosstat	-
Proportion of population using an improved sanitation facility	Regional	2008-2019	Rosstat	-
Percentage of population using solid fuels for cooking.	Not available and is not relevant			
Proportion of urban population living in slums.	Not available	Proportion of urban population living dilapidated and wreck houses 2010-2014		

Source: United Nations, 2007

In the UNCSD set of indicators education and health are separate themes and access to information is assessed in the economic development theme.

Poverty is assessed with the help of indicators, which are covering two topics: income of population and living conditions. In the UNCSD framework, poverty theme is covered by the indicators presented in table 4.1 (United Nations Commission on Sustainable Development (UNCSD), 2007).

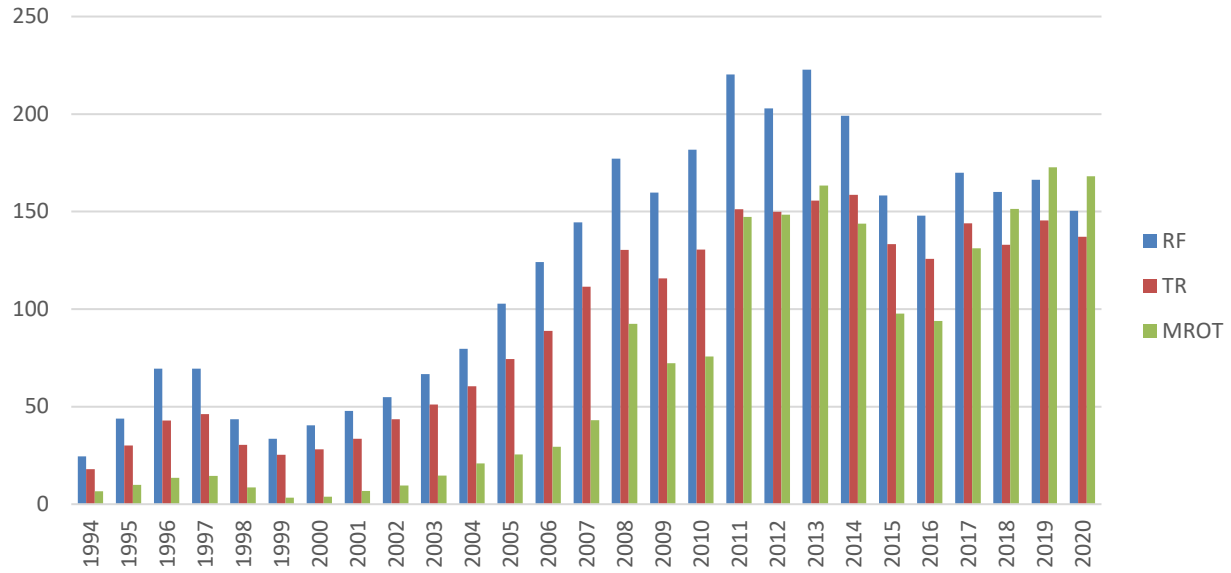
Proportion of population living below national poverty line is an indicator, which is also known as incidence of poverty or headcount index (The World Bank, 2003), it provides an insight into the progress of poverty alleviation (United Nations Commission on Sustainable Development (UNCSD), 2007).

Since 2017 Federal statistical service is collecting statistical data for the assessment of the progress towards SDGs, data is collected on the share of citizens with income lower than world poverty line adjusted by purchasing power parity (1 USD per day since 1990, 1,25 USD since 2008, 1,9 USD since 2015). The data is collected from randomly selected households, but the data is only available on national level and in 2021 there were data for 2017 and 2018 published (EMISS, 2021). The share of people with income lower than poverty line was assessed to be 1,3% in year 2017 and 0,8% in 2018 (EMISS, 2021). The share of citizens with income lower than 1,9 USD per day is very low and the poverty is usually assessed with two basic indicators that could be used as a reference point– minimal wage (abbreviated in Russian MROT – "minimal pay level") and minimal cost of living (Analytical center of government of Russian Federation, 2020).

The minimal cost of living is set up by the local administrations; it represents monetary assessment of market basket, which includes minimal set of food products, non-food commodities and services. Also it is used as a reference point for minimal wages, pensions, scholarships and other social

payments (Kulikov and Kulikova, 2009). The ministry of labour and social development in the Tambov region determines the cost of living, the cost of living is different from region to region. Minimal wage is regulated by federal law and is adjusted to the inflation rate, but some scientists admit that Russian government is committed to a low minimum wage policy (Gimpelson and Kapelyushnikov, 2013). When compared to average earnings the minimal wage equalled a mere 15% of the average wage in the first group of regions with high income and but might easily exceed 50% in the group of depressed regions with low income (Gimpelson and Kapelyushnikov, 2013). As a result of this policy, scientists argue that if the minimal wage is used as a poverty line it should be multiplied at least by 3 (Fakhrutdinova et al., 2013; Gimpelson and Kapelyushnikov, 2013; Kulikov and Kulikova, 2009; Rontoyanni, 2002; Sabetova and Kremer, 2015).

Fig. 4.2 Dynamic of cost of living (USD)



Source: EMISS, 2021

In the graph 4.2 the dynamic of cost of living could be seen. The rises and falls of the cost-of-living levels of Tambov region are repeating the fluctuation in the minimal wages level in Russia. The cost of living in Tambov region s approximately 25% lower than average country level, it is explained by the lower cost of the "Consumer basket" (the cost of goods and services) (Parkhomenko, 2006). Compared to the cost of living of other regions it could be seen that Tambov region was in a group of regions with the lowest level of cost of living. On one hand it indicates that the cost of living in Tambov region is lower compared to other regions, but on the other hand the earnings are also lower.

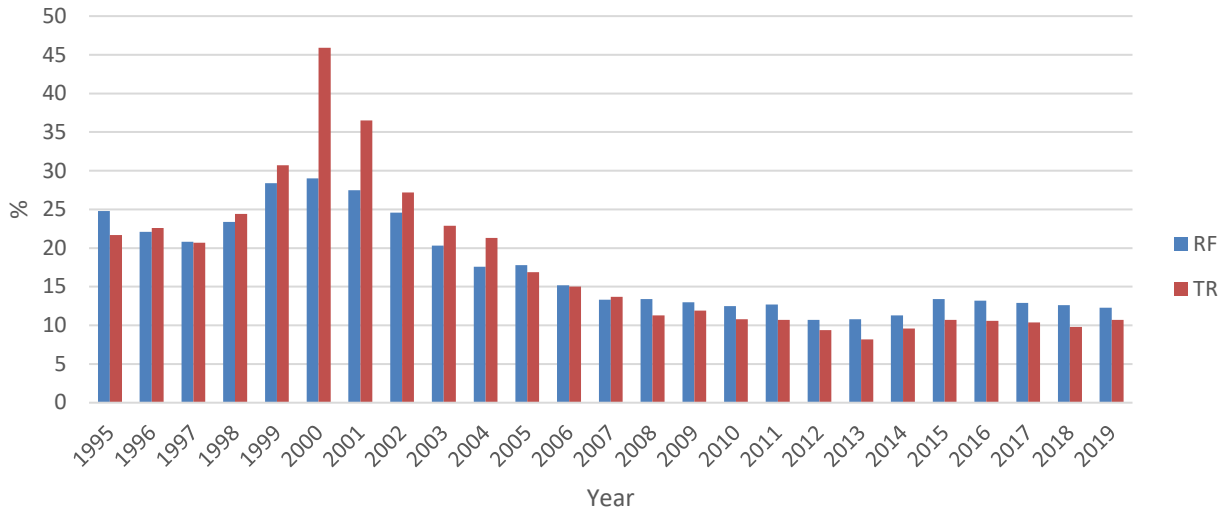
The level of cost of living had a relatively stable increase in years 1998-2008, after year 2008 the growth slowed down and since 2008 the level of cost of living is fluctuating and goes up and down from year to year. Due to economic recession the level of 2009 and 2010 did not reach the level of 2008, but then the growth continued, but in 2015 the cost of living went down below the level of 2008 again due to significant changes in exchange rates and since 2014-2015 minimal cost of living as well as minimum wage is remaining relatively stable.

If the cost of living and minimal wages are compared, it could be seen that in years 1994-2007 MROT level was fluctuating around 30 % of cost of living. This fact confirms the governmental low minimal wage strategy, but in year 2008 the MROT level doubled, and its growth continued. As a result, the MROT level reached the average Russian cost of living in year 2012 and Tambov´s level in 2015. In 2018-2020 the MROT level outrun the minimal cost of living on Russian level as well as on regional level.

There are several factors which are responsible for the changes in the level of minimal wages and

cost of living. From one hand the inflation rate is pushing up the cost of living, when the cost of living is compared in rubbles the constant growth is clear. From another hand the minimal wage and cost of living are important instruments for Russian government, the levels of both indicators are influencing the governmental payments (pensions, student scholarships, support allowances for low income population), but also it influences the situation on the labour market, and the government is trying to find an optimum level (Kulikov and Kulikova, 2009; Sabetova and Kremer, 2015).

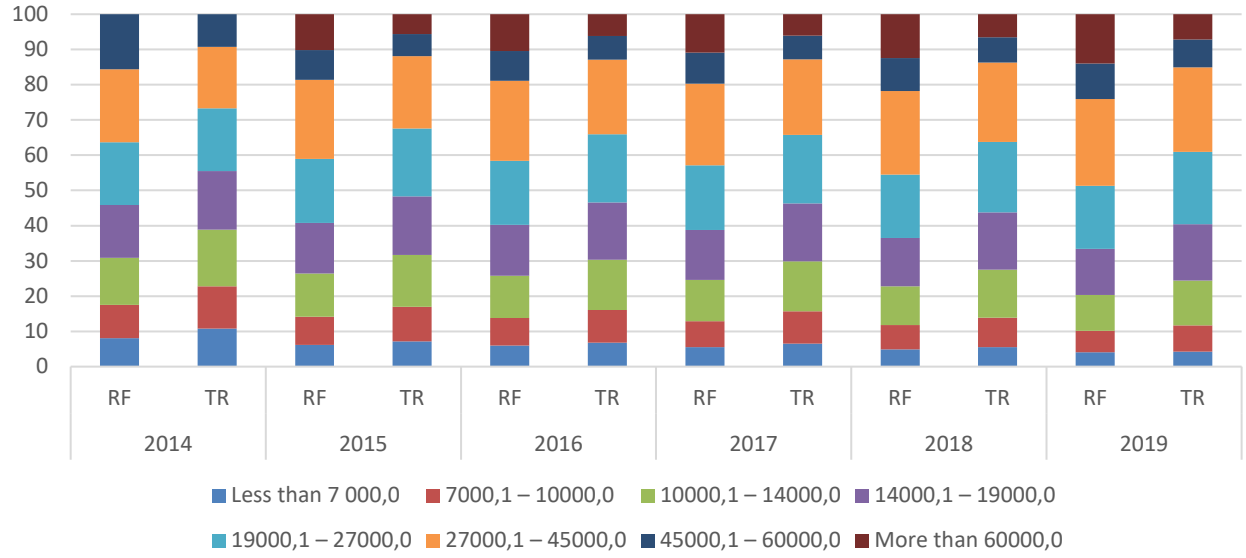
Fig. 4.3 Share of population with income lower than cost of living



Source: EMISS, 2021

The proportion of population with income lower that the cost of living was around 20 % in years 1995-2000, in year 2000 the share reached its maximum (45,9 % in Tambov and 29 % in Russia), after that the share had a stable decrease in years 2001-2007 and is slightly fluctuating around 10 % level since 2007 (Fig. 4.3).

Fig. 4.4 Distribution of income

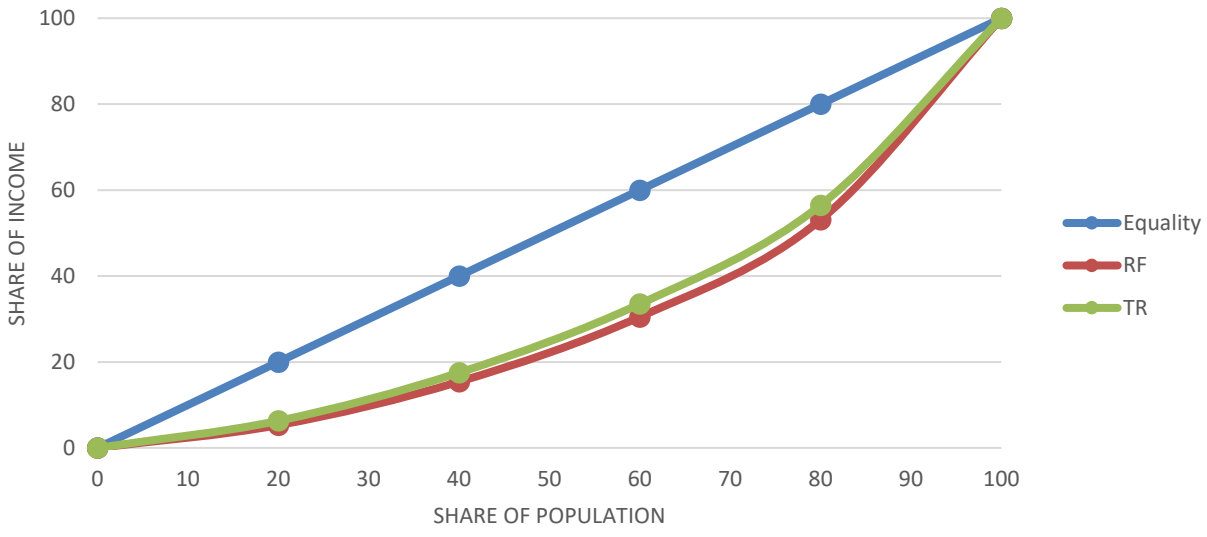


Source: EMISS, 2021

The share of the poorest population in Russia and in Tambov region has similar dynamics, but in year 2000 and 2001 the share in Tambov region was significantly higher, than on average Russian

level. In the last years the share of the poorest population was lower, than in Russia.
By the characteristic of Kulikov & Kulikova (2009) families with more than 2 children take the highest share in the group of population with income lower than cost of living and this population group is exposed to the highest poverty risk. The families without children or with only one child are in the group of "well-off "people. Voluntary national report also admitting that the structure of the poverty has changed, in year 2000 the poorest share of the population was mostly retired people, families without children or with an only child, in 2017 81 % of the households with income lower than the cost of living were families with children (Analytical center of government of Russian Federation, 2020).
Proportion of population below $ 1 per day is second indicator in the framework. The first indicator is comparing level of poverty to the local values, but the second indicator is trying to compare it to the international poverty lines (United Nations Commission on Sustainable Development (UNCSD), 2007).
The share of people living on 7000 roubles per month could be used as a substitution for the UNCSD indicator, because 7000 roubles is roughly 120 $ per month, which is 4 dollars per day (EMISS, 2019). There is no statistic on how many people are living on less than 1$ per day, but 4$ is already very poor income for Russia, which is lower than regional minimum (Titov, 2021).
On the base of the distributions of income in Russia the conclusion could be made, that the share of population with income lower than poverty line is higher in Tambov region. In year 2012 the share of population with lowest income was 20,8 % in Tambov region and 12,5 % in Russia, but due to stable decrease the share of poorest population in Tambov region is slowly overtaking the Russian level. At the same time, the share of population with highest income is significantly higher on Russian average, than in Tambov region. It means, that on an average population of Tambov region is poorer as in Russia. There is statistical data on the average level of income which is available to the poorest population. The income available to the people living in Tambov region is lower than in Russia on average (EMISS, 2019).
Ratio of share in national income of highest to lowest quintile is a share of the total volume of money income of the group of population in the total volume of money income (United Nations Commission on Sustainable Development (UNCSD), 2007). This indicator is showing the level of income inequalities in a region or a country.
The data in Tambov region almost repeats the average Russian data. In the figure 4.5 Lorenz curve is presented. It is a graphical representation of the difference between the equal and the real distribution of income (Gastwirth, 1971).

Fig. 4.5 Ratio of share in national income of highest to lowest quintile in 2019



Source: own illustration based on data from EMISS (2021)
The quintile with the highest income is earning almost 50% of all income, and the inequality gap is clearly seen on the graph. The distribution of income is relatively stable in last 5 years.
Usually, Gini coefficient is assessed when the inequality of income distribution is in question. In the case of Tambov region, the coefficient was equal to 0,369-0,412 in 2009-2019. The Gini coefficient has grown in last years, it is reasoned by growing amount of people with higher incomes (Kulikov et al., 2009) and the share of people from the first quintile is decreasing. Gini coefficient was increasing in 1994-2013, but since 2014 until 2019 it is slowly decreasing, the distribution of income is becoming more equal (EMISS, 2021).
Next indicators are covering the living conditions of the population in the region.
Proportion of population using an improved water source is necessary for poverty alleviation and to protect human health and the environment (United Nations Commission on Sustainable Development (UNCSD), 2007).
In Tambov region and in Russia there is statistical data on the share of population with an access to the safe water with a certain level of quality.
Share of population with the access to the improved water source in the last four years is relatively stable and with an average 79 % in Russia and 72% in Tambov region (EMISS, 2021).

Fig. 4.6 Proportion of population using an improved water source

Source: EMISS, 2021
The proportion of population with an accessed to safe water is relatively low for Tambov region, and it is also lower than Russian average level. Tambov region is reach of water resources, and the limited availability of safe drinking water is a problem on infrastructure level (Ecology and environment protection department, 2012).
Share of households without electricity or other modern energy services is dividing population into two groups. The first one has access to the modern sources of energy and the second one is using traditional "non-commercial" options (United Nations Commission on Sustainable Development (UNCSD), 2007).
There is no statistical data on the share of households with the access to electricity in Tambov region, because it is assumed that 100 % of households are provided with electricity (EMISS, 2021).
Proportion of population using an improved sanitation facility is a share of population with access to a private sanitary facility for human excreta disposal in the dwelling or immediate vicinity (United Nations Commission on Sustainable Development (UNCSD), 2007).
In Tambov region more than 70 % of households are equipped with improved sanitation facilities, and the share was growing since 1995 steadily, but this level is lower than average Russian level or average level of central federal region. If the difference between the rural and urban areas is

compared a conclusion could be drawn that except gas availability the difference between rural and urban areas is around 30 %. Especially the difference is big in the provision of hot water, only 25 % of rural households have access to hot water (EMISS, 2019).

Percentage of population using solid fuels for cooking. There is no statistic on the share of population, which is using solid fuels for cooking, it is considered that here is no such practice. Since all houses are provided with electricity and almost 90 % are supplied with gas it is not common to use solid fuels for cooking.

Proportion of urban population living in slums. The indicator "proportion of urban population living in slums" could be described with statistics on the share of population living in dilapidated and wreck houses. Dilapidated houses are defined as a condition in which whole buildings have a certain rate of deterioration: for stone houses – more than 70 %, for wooden over 65 %. Wreck houses are the buildings in abnormal conditions, in which more than half of main load-bearing structures (walls, foundation) are classified as in emergency condition and are posing a threat for the life of residents (State Duma, 2004).

Around 3 % of population is registered as living in dilapidated and wreck houses in Tambov region in 2010-2014, which is equal to the average Russian level (EMISS, 2019).

4.1.2 Governance

The World Bank has developed indicator system, which is called Worldwide Governance Indicators (Thomas, 2009). It covers 6 dimensions of governance:

- Voice and accountability
- Political stability and absence of violence/terrorism
- Government effectiveness
- Regulatory quality
- Rule of law
- Control of corruption.

The governance indicator combines seven indicators measuring, for example, the extent of civil liberties, political rights and independence of media, the involvement of military forces in politics and the responsiveness of government to its people as well as transparency of government decisions particularly with respect to decisions affecting and concerning business (Kaufmann et al., 1999). Data for those indicators is usually collected by expert interviews or by interviews of entrepreneurs. In the methodology sheets it is stated that theme governance is underdeveloped, and it needs revision. Significant methodological work is needed to develop good, measurable and internationally accepted indicators on other aspects of governance (United Nations Commission on Sustainable Development (UNCSD), 2007).

Now only two indicators cover topic:

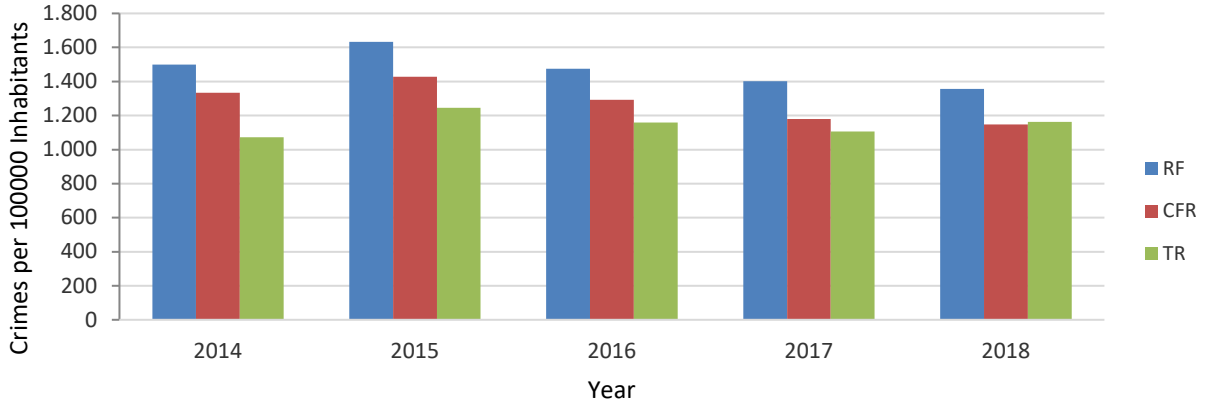
- Percentage of population having paid bribes
- Number of recorded intentional homicides per 100,000 population.

Percentage of population having paid bribes is, by the determination of UN, measuring the level of corruption (United Nations Commission on Sustainable Development (UNCSD), 2007). There is no official statistic on bribes in Russia.

Number of recorded intentional homicides per 100,000 population is covering criminal level of a region. With the help of this indicator the dimension "rule of law" is covered (United Nations Commission on Sustainable Development (UNCSD), 2007).

The number of recorded homicides is lower in Tambov region, than the Russian average and there is a decrease over last years.

Fig. 4.7 Crime rate per 100000 inhabitants



Source: EMISS, 2019a

In the figure 4.7 the crime level per 100000 inhabitants could be seen, the crime level in Tambov is more favourable than in Russia or central federal region and it remains stable (EMISS, 2021).

4.1.3 Health and well-being of people living in the region

Health and well-being of people play an important role in the sustainability of a region.

Table 4.2 Summary table of data characteristics

Indicator	Availability		Source	Substitution
	Level	Period		
Percentage of population with access to primary health care facilities.	Regional	2012-2016	Rosstat	-
Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Regional	2012-2016	Rosstat	-
Nutritional status of children	Regional	2012-2016	Rosstat	-
Immunization against infectious childhood diseases	Regional	2012-2019	Rosstat	-
Prevalence of tobacco use	Not available			
Suicide rate	Regional	2012-2016	Rosstat	-
Under five mortality rates	Not available			Under 1 mortality rate, 2006-2017
Life expectancy at birth	Regional	2012-2016	Rosstat	-
Healthy life expectancy at birth	Not available			
Contraceptive prevalence rate	Not available			

Source: EMISS, 2019a

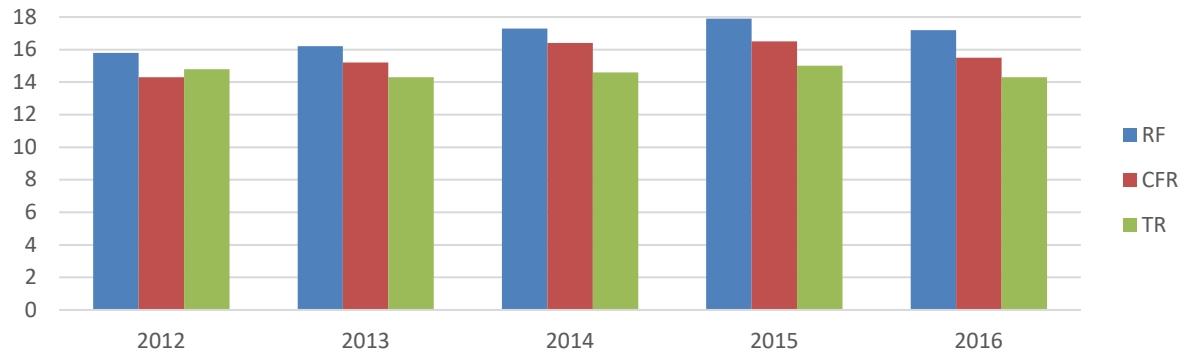
Death and ill health are directly influencing the well-being of the population and are also the brakes for economy (Wagstaff and Claeson, 2004). The topic health is covered by the indicators presented in table 4.2 (United Nations Commission on Sustainable Development (UNCSD), 2007).

Percentage of Population with Access to Primary Health Care Facilities is an indicator, which is supposed to cover not only physical availability of clinics, but also the economic, social and cultural acceptance of them (United Nations Commission on Sustainable Development (UNCSD), 2007).

In Russia every citizen has the right for health care in the guaranteed amount, provided free of charge in accordance with the program of state guarantees of the provision of free medical care to citizens, as well as to receive paid medical services and other services, in accordance with the contract of voluntary medical insurance (Ministry of health, 2011). The access to primary health care facilities could be assessed with the statistical data on the capacities of outpatient clinics per 10000 inhabitants.

The capacity is relatively stable in the region (Fig. 4.8) and is on the same level as in Russia and central federal region. The availability of outpatient hospitals is higher in Tambov region as in comparison to Russia (EMISS, 2019). According to this data the outpatient clinics are not overloaded and are accessible for the citizens.

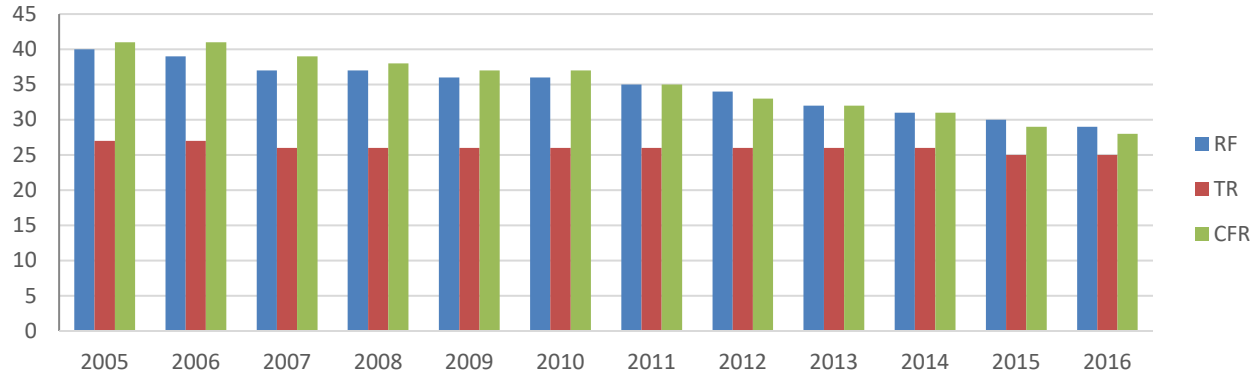
Fig. 4.8 Capacity of outpatient clinics per 10000 people



Source: EMISS, 2019a

In Russian literature the accessibility of medical services is often associated with the amount of emergency medical stations (Analytical center of government of Russian Federation, 2020, 2016). On the graph 4.9 it could be seen that amount of the stations is decreasing on Russian level as well as on federal level, but the amount in Tambov region has remained stable.

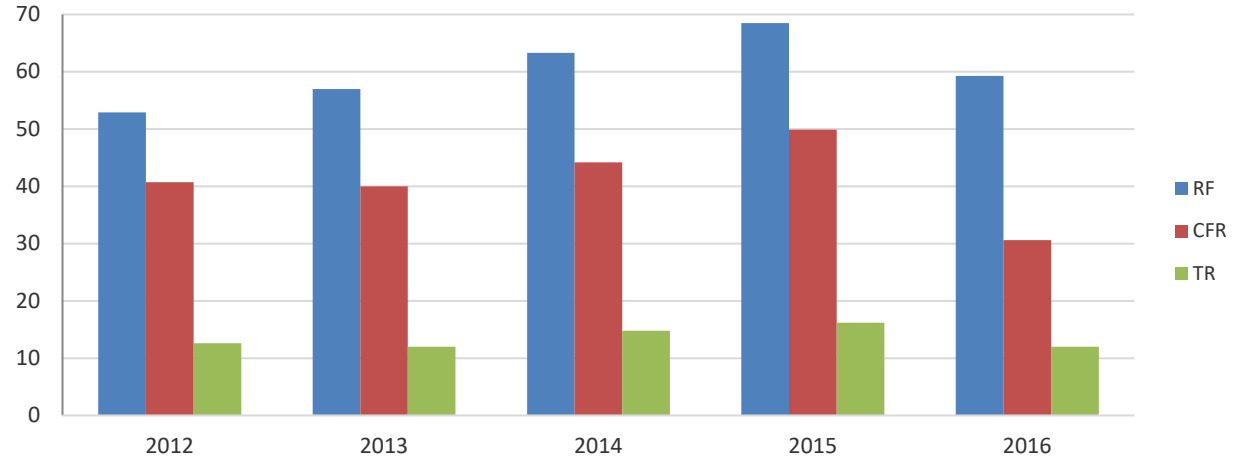
Fig. 4.9 Amount of emergency medical stations



Source: EMISS, 2019a

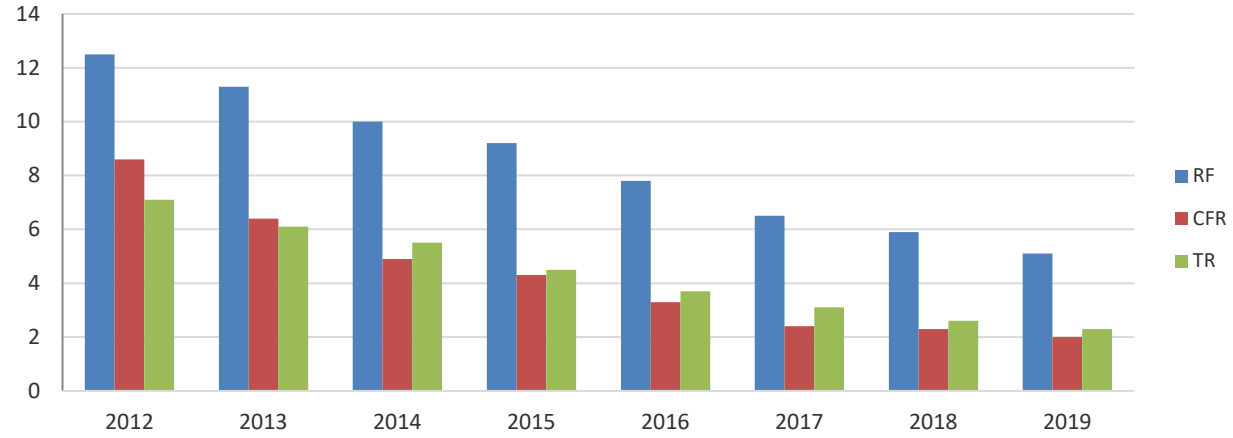
Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis is an important indicator, because the sustainability goals could not be reached in the presence of high prevalence of debilitating diseases.
Amount of people with HIV diagnosis were increasing in 2012-2015 and then there was a drop in 2016 (EMISS, 2019).

Fig. 4.10 Occurrence rates HIV per 100000 inhabitants



Source: EMISS, 2019a
Morbidity rates of tuberculosis tend to decrease in last years. Morbidity rates in Tambov region are lower than average Russian level, but it is higher than in central federal district (EMISS, 2021).

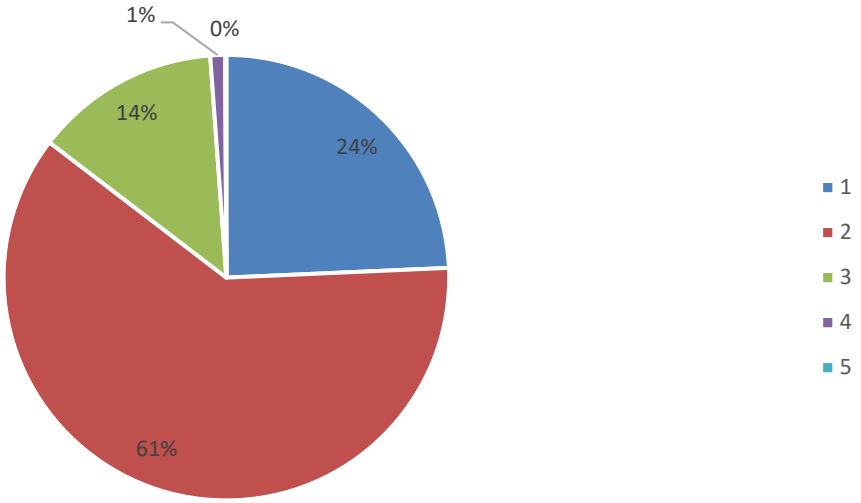
Fig. 4.11 Morbidity rates tuberculosis



Source: EMISS, 2019a
Malaria is not common for the Tambov region and for Russia. The highest morbidity rate is for the diseases of circulatory system and the second place is cancer diseases(EMISS, 2019).
Nutritional status of children is the percentage of underweight children among children under five years of age; percentage of stunting among children under five years of age; and percentage of overweight among children under five years of age (UN, 2007).
There is no official statistic on the nutritional status of children in Russia. This indicator could be substituted with the analysis of the division of children for different health groups.
Ministry of health (2003) offers 5 health groups.
First group includes healthy children with normal growth and normal level of functions, without any chronic illnesses.

Second group – healthy children, who have some functional and morphological deviations, and they have decreased resistance for acute and chronic diseases. The rest three groups of children differ in the degree, severity, and possibility of compensating for diseases.

Fig. 4.12 Health groups of children (average 2012-2016) in Tambov region



Source: EMISS, 2019a

Children and adolescents of 3rd, 4th and 5th health groups should be under medical supervision of doctors of different specialties, they should get medical and preventive care, due to the existing pathology and the degree of compensation. In educational institutions a lenient schedule should be created for them, the extended length of rest and a night's sleep, the amount and intensity of physical activity should be limited. If necessary, they are sent to special institutions for children and adolescents.

The majority (61%) of children of Tambov region is in the second health group. Also 24 % are in the first group. It means that more than 85 % of children are in good health conditions. For comparison with other region the statistic on the proportion of children belonging to the second health group is used. The share of children of second health group in Tambov region is slightly higher than average Russian level.

Table 4.3 The percentage of population covered by the immunization.

Disease		2012	2013	2014	2015	2016	2019
Hepatitis	Russia	97,8	97,18	96,61	97	96,92	97,37
	Tambov region	97,9	97,4	97,34	97,9	98,15	98,21
Diphtheria, whooping cough, tetanus	Russia	97,9	97,7	97,29	97,49	97,42	97,29
	Tambov region	98,1	98	97,49	98,01	97,83	97,89
Measles	Russia	98,6	98,5	98,23	98,23	98,08	99,11
	Tambov region	98,7	98,6	98,5	98,6	99,39	99,81
Rubella	Russia	98,5	98,4	98,18	98,22	98,05	98,03
	Tambov region	98,7	98,6	98,51	98,63	99,39	98,58

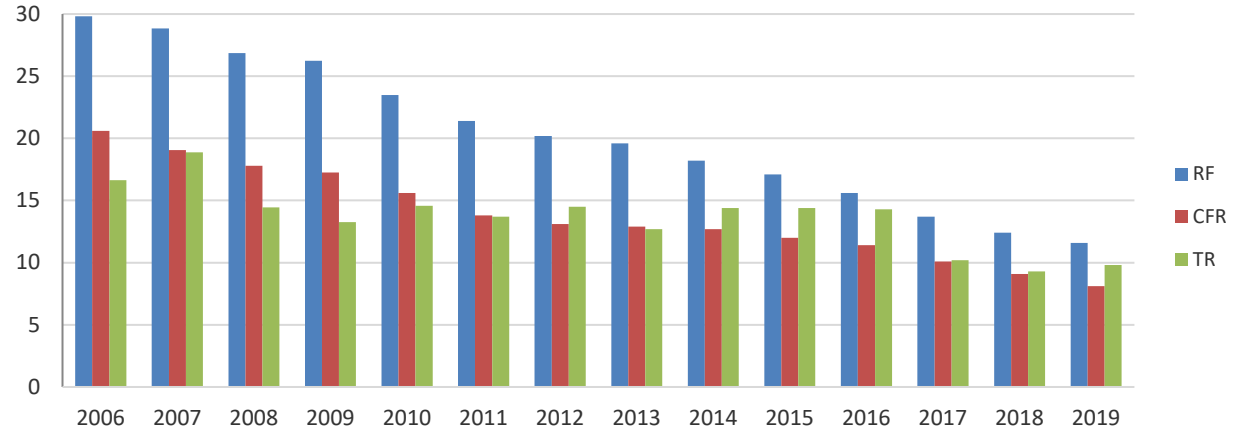
Source: EMISS, 2021

Immunization against infectious childhood disease is the proportion of children immunized against diphtheria, tetanus, pertussis, measles, poliomyelitis, tuberculosis, and hepatitis B before their first birthday and the proportion of women of child-bearing age immunized against tetanus. The rates of immunisations are very near to 100 % in Russia and in Tambov region (EMISS, 2021). The management of immunisation programs could be assessed as effective.

Prevalence of tobacco use is an indicator is defined as the percentage of the population aged 15 years or older that daily smokes any tobacco product. It is calculated from the responses to individual or household surveys that are nationally representative. There is no statistic on the regional level on the tobacco use. In 2012 Russia took the second place in the rating of countries with highest prevalence of tobacco use, but in 2013 the measures against tobacco use were implemented. Smoking was prohibited in public places, the cigarettes are now only available in the shops, the taxes were increased, advertisements of cigarettes were prohibited (Zasimova and Matýanov, 2012). In 2013 39,1% of population was smoking (60,2% of male and 21,7% of female population). The share of smoking population decreased to 31% in 2016 (EMISS, 2019).

Suicide rate is the number of deaths from suicide and intentional self-harm per 100 000 people. Suicide rate in Tambov was 9,8 per 100 000 population in 2019, which is stably lower than average Russian level (11,6 in 2019), but higher than level in Central federal region (8,1 in 2019) (EMISS, 2021).

Fig. 4.13 Suicide rate



Source: EMISS, 2021

Under five mortality rate refers to the probability of dying before age 5. It is expressed as deaths per 1,000 live births (United Nation 2007).

Fig. 4.14 Under one mortality rate

Source: EMISS, 2019a

In Russia the statistical data on child mortality rate is only available for children under 1 year. The probability of death from birth to 1 years per 1000 decreased from 9,4 in 2006 to 2,4 in 2017. Average Russian level is 10,2 and 5,5 in these years. In Tambov region the mortality rate is lower than on federal level and on Russian level.
In Russian Federation another indicator played an important role – maternal death rate. This rate was especially high in 1990th (10 times higher than in European countries), but by a consequent work of health departments, the rate decreased significantly (Analytical center of government of Russian Federation, 2016).
Life expectancy at birth is the average number of years that a new-born could expect to live, if he or she were to pass through life subject to the age-specific death rates of a given period.
The average figure is 72 in Russia; at the same time for male the life expectancy is 67 years and female 77 in 2019 (EMISS, 2021). The life expectancy is slowly growing in last years. It is interesting that a difference between male and female life expectancy is so high, especially when Russia is compared to other developed countries it could be seen that such a difference is not typical (Analytical center of government of Russian Federation, 2016).
Healthy life expectancy at birth is an average equivalent number of years of full health that a new-born could expect to live, if he or she were to pass through life subject to the age-specific death rates and ill-health rates of a given period. The healthy life expectancy of birth is 53,8 years in Russia in year 2015 (Scherbov and Shulgin, 2018). As was already mentioned there is a difference in the life expectancy between female and male population, but the healthy life expectancy the difference is not significant 52,3 years for male and 55,3 for female in 2019 (EMISS, 2021).
Contraceptive prevalence rate is an indicator is generally defined as the percentage of women of reproductive age (15-49 years) using any method of contraception at a given point in time. The only data which is collected connected to this matter is the share of women of reproductive age (18 to 44 years), whose family planning needs are satisfied by modern methods, the data for this indicator is calculated in based on results of surveys, which are carried out every 5 years since 2012. The last data available is form year 2017, the indicator was equal to 74,7 % on Russian level, the data on regional level was not available (EMISS, 2021). This indicator could be substituted with abortion rate, which is available.

4.1.4 Education

Theme education is covered with help of the indicators presented in table 4.4 (UN, 2007), the statistical data for most indicator in this sphere is not available, there are some indicators which could be used as substitutions, but still the theme is covered poorly.
Gross intake rate into last year of primary education is total number of new entrants in the last grade of primary education, regardless of age, expressed as a percentage of the population of the theoretical entrance age to the last grade of primary education. The indicator is also called Primary Completion Rate. Unfortunately, it is not available for Russian Federation.
Net enrolment rate in primary education is the ratio of the number of children of official school age (as defined by the national education system) who are enrolled in primary school to the total population of children of official school age.
Statistical data for first two indicators is not available, but following data is available:

- Availability of places in pre-school educational organisation for children of pre-school age
- Total number of children not enrolled in educational institutions
- Public satisfaction with the quality of school education.

The indicator availability of places in pre-school educational organisation is showing how many places are available per 1000 children (EMISS, 2019).

Table 4.4 Summary table of data characteristics

Indicator	Availability		Source	Substitution
	Level	Period		
Gross intake rate into last year of primary education	Not available	Availability of places in pre-school educational organisation for children of pre-school age Total number of children not enrolled in educational institutions Public satisfaction with the quality of school education.		
Net enrolment rate in primary education	Not available			
Adult secondary (tertiary) schooling attainment level	Only census data			
Life-long learning	Not available			
Adult literacy rates	No dynamic data			

Source: UN, 2007

Amount of place in pre-school educational organisations is mostly slowly growing, but it is fulfilling the demand only for less than 70 %.

Table 4.5 Availability of places in pre-school educational organisation for children of pre-school age

	2013	2014	2015	2016	2017
Russian Federation	600	612	626	635	633
Central federal region	643	648	651	649	641
Tambov region	641	681	752	756	777

Source: EMISS, 2019a

The number of children (age 5-17 years) not studying in educational organisations has decreased almost in 1,5 times in last 5 years, but the share of children who did not finish 9 years of education is still relatively high (Analytical center of government of Russian Federation, 2016).

Adult secondary (tertiary) schooling attainment level is defined as the proportion of the population of working age (25-64 years), which has completed at least (upper) secondary education.

In Tambov region situation with education is characterised by following figures:

- 22,5 % of employed citizens have higher education (0,1 % of them are post-graduates)
- 78% have at least the upper secondary education
- Adult secondary schooling attainment level was more than 90 % in 2010, which is relatively high (EMISS, 2019).

If the figures in Russia and central federal region are compared a conclusion could be made, that the rates in Tambov region are lower in the post-graduate, graduate, and primary vocational education. Among employed people in Tambov region the majority has vocational and upper secondary education, the rates for citizens without education are also higher, than in Russia and CFR on average.

Table 4.6 Education attainment level among employed citizens 2010.

	With education						Without education
	Post-graduate	Graduate	Vocational	Primary vocational	Upper secondary	Secondary	
Russian Federation	0,2	28,7	27,1	19,7	20,0	4,0	0,3
CFR	0,3	33,9	28,2	17,8	16,9	2,7	0,2
Tambov region	0,1	22,4	31,5	17,4	23,2	4,8	0,6

Source: EMISS, 2019a

Statistics concerning education level is only collected during population census, which was conducted in 2010.

In 2020 a census was conducted, but the results were not yet available during preparation of this thesis.

Lifelong learning is percentage of the population aged 25 to 64 in education or training. There is no statistical data on the share of population, which is educated or trained in the age 25-64. Data on this indicator is not available.

Adult literacy rate is the proportion of the adult population aged 15 years and over that is literate. 99.49 % of population of Tambov region are literate (EMISS, 2019). The data in dynamics is also not available.

According to the progress report on achieving sustainable development goals, the main goal is achieved, primary education is available for all citizens and Russia takes leading positions on the level of education in the world. But there is a problem with oversupply of specialist with university degrees especially in liberal arts and deficit of the specialist with technical education (Analytical center of government of Russian Federation, 2016). The main reason is the lack of communication between higher education system and labour market (Bedrickij, 2012). The inconsistency of the education system with the structure and requirements of the labour market leads to an increased level of youth unemployment and is also a problem for sustainability development which should be covered by indicators.

4.1.5 Demographics

Demographics have been considered about three measures of growth in relation to population, fertility, and dependency ratios. Theme education is covered with help of the indicators presented in table 4.7 (UN, 2007).

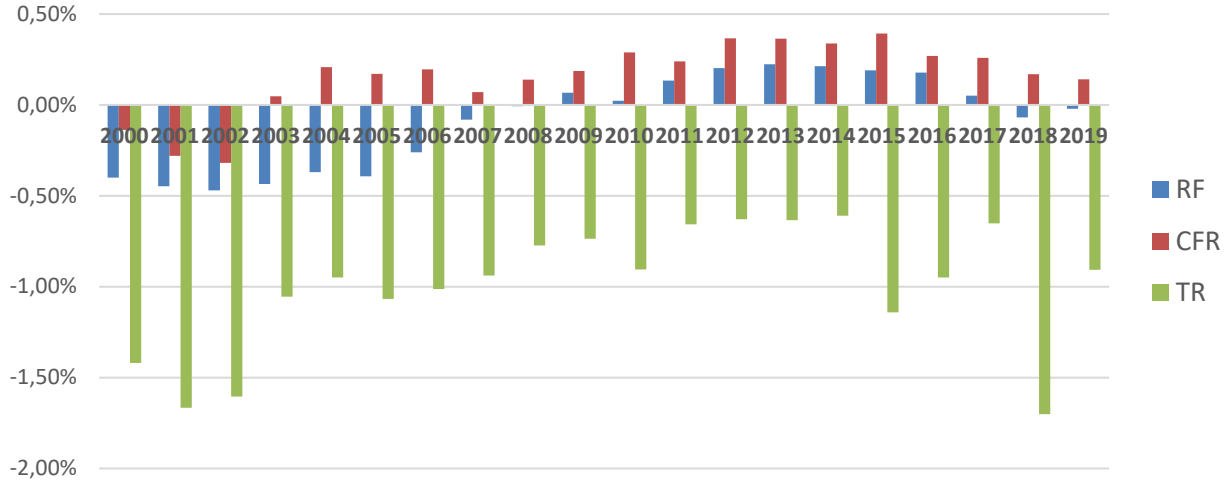
Table 4.7 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Population growth rate	Regional	2012-2019	Rosstat
Total fertility rate	Regional	2012-2016	Rosstat
Dependency ratio	Regional	2012-2016	Rosstat
Ratio of residents to tourists in major tourist regions and destinations	Not available		

Source: EMISS, 2019a

Population growth rate is average annual rate of change of population size during a specified period.

Fig. 4.15 Population growth rate.



Source: EMISS, 2021

The population growth rate is negative since 1993 until 2008 in Russia, but in 2009 the population has started to grow and in the last five years the growth rate was positive until 2017, in 2018 and 2019 the population growth rate was negative. The population of Tambov region has negative growth rate in the period 1993 until 2019 (EMISS, 2021). By the birth rate Tambov region takes only 78th place among all Russian regions in 2016.

Total fertility rate is average number of children (live births) a cohort of women would have at the end of their reproductive period if they were subject to the age-specific fertility rates of a given period. The total fertility rates are showing that the Tambov region is in the end of list of all Russian regions with only 1.3 child per woman, the average fertility rate is 1,5 in 2019 (EMISS, 2021).

Fertility rates in rural areas are higher than in urban areas in all age segments. It is a positive sign for growth rate, but it could be a problem in the context that families with two and more children are in the poverty risk group (Kulikov and Kulikova, 2009).

Dependency ratio relates to the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old). It indicates the potential financial burden in terms of pensions and costs of care systems for the elderly (Ledoux et al., 2005).

For Russian Federation the dependency ratio is calculated as ratio between working population and unemployed population.

In table 4.8 the dependency ratio for Tambov region, central federal region and Russian federation is presented, it could be seen that in Tambov region there are more working people per 1000 unemployed.

Table 4.8 Dependency ratio

	2012	2013	2014	2015	2016
Russian Federation	664	687	713	740	764
CFR	665	686	709	735	759
Tambov region	715	734	754	789	813

Source: EMISS, 2019a

The dependency ratio in rural areas is higher than in urban areas. The economically active population and the overall economy may face a greater burden in supporting the young and/or older economically dependent populations.

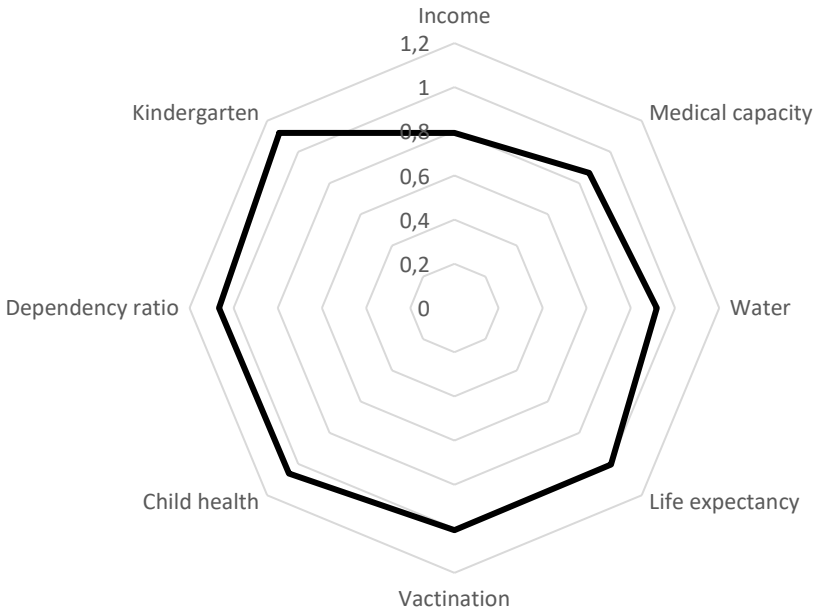
4.1.6 Overview for social pillar of sustainability

UNCSD framework is offering to use 31 indicators to access social pillar of sustainability. In the chapter 4.1 the overview and analysis of available statistical data was presented to sum up the analysis in the figure 4.14 and 4.15 a polygon for social sustainability is presented. For creation of the polygon an average level of the indicators in 2012-2016 in Tambov region was compared to the corresponding average of indicator on Russian level.

For clarity the indicators are divided in positive and negative groups. "Positive" indicators are indicators which higher value is strengthening the sustainable development and "negative" is working in opposite direction.

In the figure 4.16 8 positive indicators are presented, and half of the indicators are exceeding average Russian level, the rest is in the range of 0,8-1. Tambov region exceeds average Russian level on such indicators as child health, availability of places in kindergarten and dependency ratio. These indicators could be considered as strengths of the region. On the other side income in Tambov region equals only 0,8 of average Russian level and the key question is if low income could be compensated with other indicators. On the other side the cost of living is 25 % lower than average country level and the Tambov region is in a group of regions with the lowest level of cost of living.

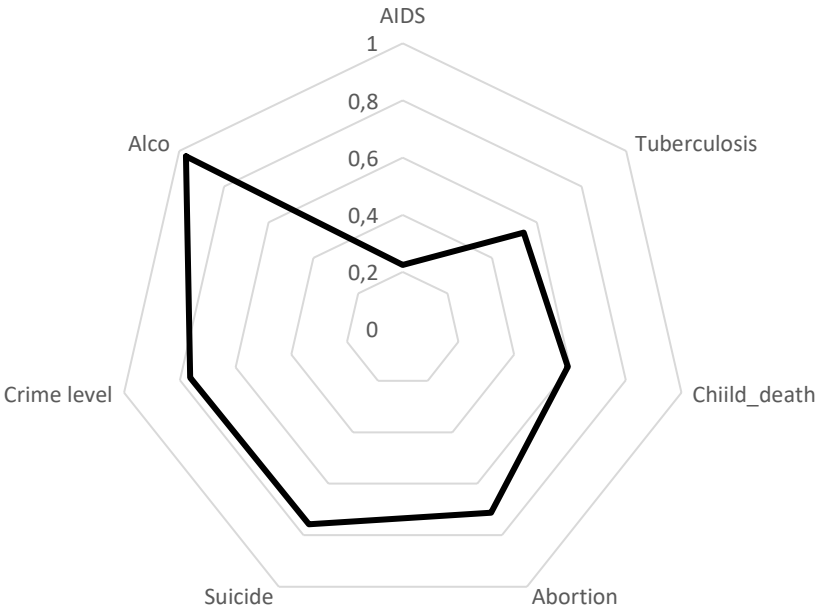
Fig. 4.16 Polygon for social pillar, positive indicators



Source: own illustration

In the figure 4.17 7 negative indicators are presented, all of them are below average Russian level. Only indicator Alco (it is measuring the level of morbidity of alcoholism) is almost on average Russian level. The indicators *AIDS* and *Tuberculosis* are showing low level, which is contradicting with the availability of medical help, which is lower than Russian level.

Fig. 4.17 Polygon for social pillar, negative indicators



Source: own illustration

When the social indicators are assessed all together a conclusion could be drawn that Tambov region is performing slightly higher than average Russian level and the main strength of the region lies in the human potential.

4.2 Ecological sustainability

4.2.1 Natural hazards

With the natural hazard theme, the ecological dimension of sustainability is started. In the early editions of the UNCSD indicators natural hazards were a sub-theme in the governance sector, but in the 2007 edition it dissolved into separate theme (United Nations, 2007).

Natural hazard theme is covered with the help of two indicators:

- Percentage of population living in hazard prone areas
- Human and economic loss due to disaster.

This theme is trying to assess the possibility natural catastrophes in the region and potential economic and human losses. With the dynamic data on this issue the success of the catastrophe's management is assessed, and the level how well the region is prepared for the disasters (United Nations, 2007).

Percentage of population living in hazard prone areas is the percentage of national population living in areas subject to significant risk of prominent hazards: cyclones, drought, floods, earthquakes, volcanoes, and landslides. Tambov region is not considered as hazard prone areas, ant there is no statistical data collected concerning this issue (Ministry of Emergency Situations of Russian Federation, 2018).

Human and economic loss due to disasters is the number of persons deceased, missing, and/or injured as a direct result of a disaster involving natural hazards; and the amount of economic and infrastructure losses incurred as a direct result of the natural disaster. In Russian statistics the human and economic loss is encompassing not only natural hazards, but also man-made emergencies. Emergency is defined as a situation in a certain area, which is caused by an accident, a dangerous natural phenomenon, natural or other disasters, this situation may lead to human death as well as damage to human health or the environment, significant losses and disruption of living

conditions (Ministry of Emergency Situations of Russian Federation, 2018). The ministry of emergency situations of Russian Federation is taking the decision if the situation could get status of emergency or not. The terrorist's attacks are also included in emergency situations. In the table 4.9 the statistics concerning human loss due to emergency situations is presented.

Table 4.9 Human loss due to emergency situations

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
RF	734	683	791	832	620	567	699	788	556	717
CFR	98	92	175	91	61	98	101	102	92	160
TR	5	7	5	0	0	5	3	16	4	5

Source: EMISS, 2019a

In Tambov region in 2017 there were 4 disasters – 3 of which were man-made and 1 biological and in 2017 the human loss was the highest in last decade (Ministry of Emergency Situations of Russian Federation, 2018). Human loss due to emergency is different from year to year, but the ministry of emergency situations is implementing measures to reduce the number of emergencies and losses caused by them.

In the table 4.10 the potential risks of disasters are presented (Ministry of Emergency Situations of Russian Federation, 2018).The level death risk in case of fire emergency in Tambov region is lower than allowable level set by state Russian standard (GOST). The risk of death on water objects is relatively allowable, which means that the difference between GOST-value and average level of risk is not higher than 1/3 of average Russian risk (Ministry of Emergency Situations of Russian Federation, 2018).

Table 4.10 Risk of death in different emergency situations in 2017

	Individual risks of death				
	Fire	Emergency situations	Allowable by GOST	On water objects	Average
RF	$4{,}999*10^{-5}$	$3{,}929*10^{-6}$	Not set	$2{,}476*10^{-5}$	$7{,}868*10^{-5}$
Moscow	$9{,}244*10^{-6}$	$1{,}849*10^{-6}$	$6{,}420*10^{-6}$	$4{,}984*10^{-6}$	$1{,}608*10^{-5}$
Tambov region	$5{,}206*10^{-5}$	$3{,}856*10^{-6}$	$8{,}150*10^{-6}$	$2{,}603*10^{-5}$	$8{,}194*10^{-5}$

Source: EMISS, 2019a

In Tambov region the main man-maid emergencies are fires in industrial or residential buildings, accidents in gas supply systems, and car accidents. For economic loss in agriculture and forestry the main reasons are hail, hurricane winds, anomalous temperature fluctuations, heavy rains, floods, and regularly recurring droughts, but there is yearly statistical data on the amount of economic loss (Ministry of education and science of Russian Federation, 2017). Overall country loss in 2016 was equal to 10,45% of GDP (EMISS, 2019).

4.2.2 Atmosphere

Atmosphere theme is covered by 4 following indicators presented in the table 4.11 (UN, 2007).

Table 4.11 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Carbon dioxide emissions	Regional	2000-2017	Regional ministry
Emissions of greenhouse gases	Not available		
Consumption of ozone depleting substances	Not available		
Ambient concentration of air pollutants in urban areas	Regional	2005-2017	Regional ministry

Source: UN, 2007

Carbon dioxide emissions measures the emissions of carbon dioxide, which is known to be the most important, in terms of impact on global warming, anthropogenic greenhouse gas (GHG).

Table 4.12 Emissions of the most spread polluting substances, from stationary source, thousand tonnes

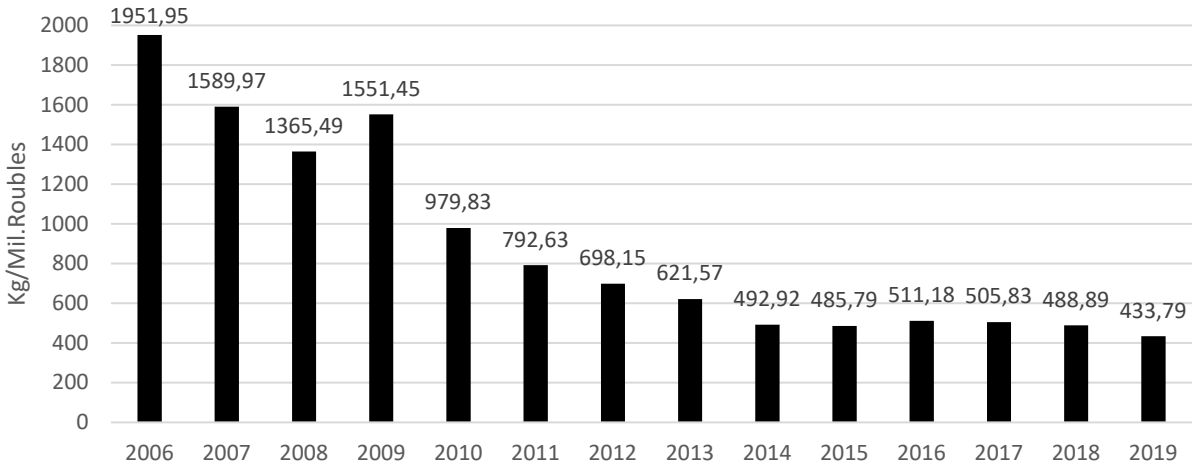
	2000	2005	2010	2013	2014	2015	2016	2017	2018	2019
Total	25,8	27,3	46,2	53,9	44,7	56,4	56	62,9	56	72,9
Including hard substances	3,1	2,0	3,0	4,1	4,6	4,0	4,5	4,4	3	3,6
Gas and liquid substances	22,7	25,3	43,2	49,8	40,1	52,4	51,5	58,4	53	69,2
Out of them:										
Sulphur dioxide	6,7	3,8	1,3	0,8	0,9	0,7	0,8	0,8	0,5	0,8
Carbon dioxide	6,7	8,3	11,0	13,7	12,5	13,7	13,8	10,3	9,1	11
Nitric oxide	4,5	5,0	4,4	4,5	4,0	3,7	3,7	4,2	3,7	4,3
Hydrocarbons (without organic volatile matter)	1,0	5,2	23,9	26,6	17,6	28,8	26,9	33,8	32,1	46,9
Organic volatile matter	3,2	2,1	2,1	2,1	1,6	1,4	1,8	2,9	2,6	3,2

Source: Ministry of natural resources and ecology Tambov region, 2020

In the table 4.12 the data available concerning air pollution is presented. The data collected by ministry of environment protection is not exactly responding to the atmosphere indicators of UN CSD, but some statistical data is available. There is a stable growth of air pollution, since 2000 amount of pollution has almost tripled, ministry is explaining it by the economic growth (Ministry of natural resources and ecology Tambov region, 2020).

The ministry of natural resources and ecology of Tambov region is assessing the growth of emissions as not significant and is stating that amount of emission per GDP is declining. The carbon dioxide emission of Tambov region is less than 1 % of all emissions in Russia. 52 % of all emissions are the transport emissions and 27% processing industry (Ministry of natural resources and ecology Tambov region, 2020).

Fig. 4.18 Air pollutions per GDP



Source: Ministry of natural resources and ecology Tambov region, 2020

The main cause of air pollution is transport, which is producing 65,1 % of all emissions in 2019 (Ministry of natural resources and ecology Tambov region, 2020).

Number of cars and other automotive transport has a stable, but retarding growth. Due to the growing quality of cars and use of modern technologies the emissions are decreasing, despite of the increasing number of cars (Ministry of natural resources and ecology Tambov region, 2020).

Table 4.13 Emissions of automotive transportation

	2000	2005	2011	2012	2013	2014	2015	2016	2017	2018
Emissions thousand tonnes	169,6	131,5	96,8	90,4	93	96,1	97,7	102,8	102,7	105,5
% Of all emissions	86,8	82,8	67	63,5	63,1	68,2	63,2	64,6	61,9	65,1

Source: Ministry of natural resources and ecology Tambov region, 2020

In Russia overall due to economic remission the emissions were reducing in the year 1990-1998, but it was followed by stable increase in the period 1998-2009, but in 2010 the level went down. Also it should be admitted that growth of the emission in the 1998-2009 was always behind the growth of GDP, which is reasoned by the improvement of technical equipment and materials (Ministry of natural resources and ecology Tambov region, 2018).

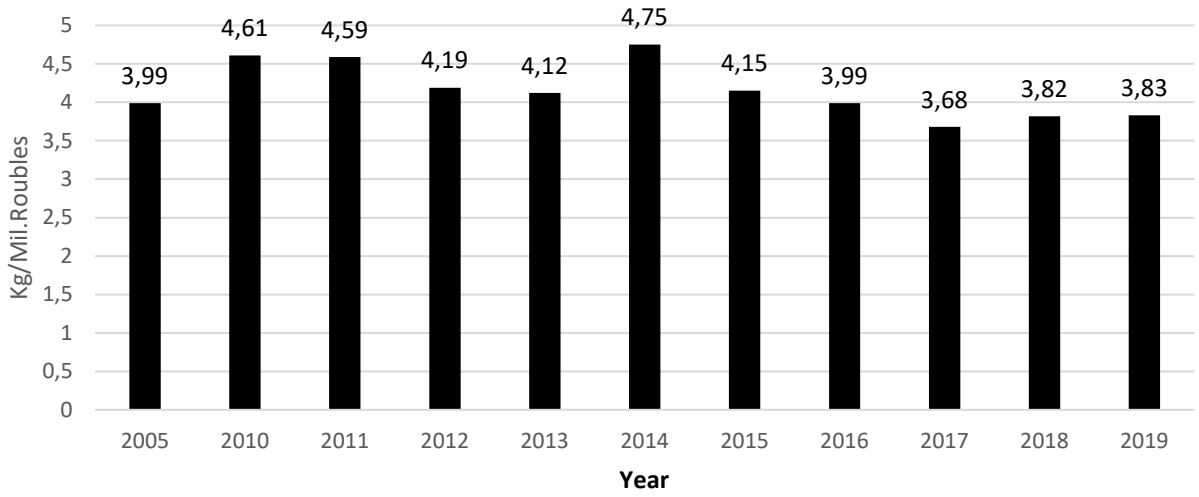
Emissions of greenhouse gases indicator measures the emissions of the six main GHGs, which have a direct impact on climate change (United Nations, 2007). The emissions are not controlled by government the increases and decrease are only reasoned by the economic climate.

Consumption of ozone depleting substances indicator shows the consumption trends for ozone depleting substances controlled under the Montreal protocol on substance that deplete the ozone layer (United Nations, 2007). Despite of the fact that Russia has ratified the protocol in 1991 the statistic is not available (Kokin and Shumakova, 2009).

Ambient concentration of air pollutants in urban areas is an air pollution concentration of ozone, particulate matter (PM10, and PM2,5, if those are not available: SPM, black smoke), sulphur dioxide, nitrogen dioxide, lead.

Additional air pollutants are carbon monoxide, nitrogen monoxide and volatile organic compounds including benzene (vocs). The indicator provides a measure of the state of the environment in terms of air quality and is an indirect measure of population exposure to air pollution of health concern in urban areas (United Nations, 2007). The priority is on collection of the data for this indicator in large cities.

Fig. 4.19 Dynamics of complex index of air pollution in Tambov city.



Source: Ministry of natural resources and ecology Tambov region, 2020

In the figure 4.19 dynamic of complex index of air pollution is presented. The complex index of pollution is calculated on the yearly level of pollutions. The level of pollutions is assessed as low, and it is also decreasing in the last years. The air is assessed as "relatively clean" (Ministry of natural resources and ecology Tambov region, 2018).

During last year average concentration of polluting substances were relatively stable. By the data of Tambov hydro meteorological centre, the level of pollution is assessed as low, the pollution with heavy metals is not higher than related norms. In the last three years (2014-2017) the level of air pollution is assessed as stable (Ministry of natural resources and ecology Tambov region, 2018).

4.2.3 Land

Agriculture plays an important role in the rural areas and land is among others one of the critical factors which influencing the yield and income of the farmers.

Table 4.14 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Land use change	Regional	2014-2019	Regional ministry
Land degradation	Regional	2013-2017	Regional ministry
Land area affected by desertification	Not available and not relevant		
Arable and permanent crop land area	Regional	2012-2019	Federal statistic
Fertilizer use efficiency	Regional	2001-2003 and 2017	Regional ministry
Use of agricultural pesticides	Regional		Regional ministry
Area under organic farming	Not available		
Proportion of land area covered by forests	Regional	2000-2019	Federal statistic
Forest trees damaged by defoliation	Not available		
Area of forest under SFM	Not available		

Source: UN,2007

Sustainable management of land is an important issue in the aim of reaching sustainable development.
In the UN CSD set the indicators are introduced to assess the character of land use and forestry (United Nations 2007). The overview over data availability is presented in the table 4.14.
Land use change indicator measures changes of the distribution of land uses within a country over time (United Nations 2007).
The status of different land types has stayed stable in the 2014-2019, there were slight changes between agricultural and land of settlements industry (Ministry of natural resources and ecology Tambov region, 2020).
Land degradation indicator represents the share of land, which due to natural processes or human activity is no longer able to sustain properly an economic function and/or the original ecological function. Degraded land includes land affected by soil erosion, deterioration of the physical, chemical, and biological or economic properties of soil and/or long-term loss of natural vegetation (United Nations 2007).
There are some negative processes, which are leading to soil degradation, the soil is susceptible to erosion, wetland, swamped and there are also some saline areas. 27 % of land is under the negative influence, which is caused by improper human use. 14,9 % is under erosion, 5,6 % is wetland (Ministry of natural resources and ecology Tambov region, 2018).

Table 4.15 Land under negative influence 2017

Negative process	Land degradation	
	1000 ha	% Of agricultural land
Water erosion	286,03	10,15
Wind erosion	172,31	6,11
Wetland	252,12	8,95
Saline	1,5	0,05
Swamped	195,2	6,93
Sour	1185,7	42,07
Solonci	13,7	0,49
Ruined	1,7	0,06

Source: Ministry of natural resources and ecology Tambov region, 2018
Area under negative influence is reported by ministry of natural resources and ecology every year and in year 2013-2017 the area has not changed. The reason for this stability could be a lack of monitoring and control, and ministry is assuming that the degraded area has not changed. This is an important indicator, which should be monitored regularly and lack of information on this indicator could distort the sustainability assessment.
Arable and permanent crop land area is the total of “arable land” and “land under permanent crops” (United Nations 2007). This indicator shows the amount of land available for agricultural production and, inters alia, the cropland area available for food production.
Tambov region is rich with high quality soil resources. 79 % of all land is in agricultural use and 64 % of is arable land. 91 % is black soil with an average 6,5% of humus content (Ministry of natural resources and ecology Tambov region, 2020).
Fertilizer use efficiency indicator measures the extent of fertilizer use recovery in agriculture per crop unit. This indicator shows the potential environmental pressure from inappropriate fertilizer application.

Fertilizer use was drastically changing, in 1986-1990 yearly fertilizer intake was 100 kg/ha, in 2001-2003 only 4 kg/ha and in 2017 it increased to 63,8 kg/ha. But still the ministry of natural resources and ecology is reporting that nutrient balance in agricultural land was negative in 2017-2019 (Ministry of natural resources and ecology Tambov region, 2020, 2018).

Use of agricultural pesticides in metric tons of active ingredients per unit of agricultural land area. This indicator measures the use of pesticides in agriculture, which is linked to the intensification of agriculture. Whereas pesticides may increase agricultural production, they pose challenges to health and environment. Pesticides tend to accumulate in the soil and in biota, and residues may reach surface and groundwater through leaching. Humans can be exposed to pesticides through food (United Nations Commission on Sustainable Development (UNCSD), 2007).

The analysis of fertilizer and pesticides residuals are showing that the level of pollution is very low (Ministry of natural resources and ecology Tambov region, 2018).

Residual of pesticides:

- Chlor-organic pesticides 0,00-0,01 mg/kg of soil (0,0-0,1% of norm)
- Phenoxy-carboxylic acids 0,0000-0,0012 mg/kg (0,00-1,20% of norm).

The researches of plant for the content of pesticides residuals and heavy metals are also on very low level 0,00-0,008 mg/kg (0,00-0,08% of norm) (Ministry of natural resources and ecology Tambov region, 2018).

Area under organic farming is ratio of total utilized agricultural area occupied by organic farming to total utilized agricultural area (United Nations Commission on Sustainable Development (UNCSD), 2007).

Officially there is no organic farming in the region; the market of organic food is underdeveloped in Russia. Also, the certification system is not ready yet to confirm the quality of final products (Navarski et al., 2014).

Proportion of land area covered by forests the indicator measures the share of forest area in total land area.

374700 of ha are covered with forests, this equals to 10,5 % of all land, forest area was stable in 2014-2019 (Ministry of natural resources and ecology Tambov region, 2020).

Forest trees damaged by defoliation is defined as the percentage of trees on forest and other wooded land in the defoliation classes moderate, severe and dead (United Nations Commission on Sustainable Development (UNCSD), 2007).

There is no official statistic on the defoliating trees in Tambov region, but even by visual assessment this problem should be treated, and statistic should be collected (Bessonov, 2014).

Area of forest under sustainable forest management is an indicator, which measures the forest area that is under sustainable forest management (United Nations Commission on Sustainable Development (UNCSD), 2007).

Sustainable forest management is a difficult term to define in Russian condition. There is no official program for such forest development, there only separate measure. For example, there are some areas under the treatment, in this context it is the area where new trees are artificially planted. The area under the treatment in Tambov region has decreased almost twice and is on the relatively low level since year 2000. Not even 1% of all forests are under the treatment (Ministry of natural resources and ecology Tambov region, 2020).

4.2.4 Water resources

Water scarcity is an issue in many developing countries. For the assessment of water availability, the indicators are presented in table 4.16 (United Nations 2007).

Proportion of total water resources used is the total annual volume of groundwater and surface water withdrawn from its sources for human use (in the agricultural, domestic, and industrial sectors), expressed as a percentage of the total volume of water available annually through the hydrological cycle (total renewable water resources) (United Nations 2007).

Table 4.16 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Proportion of total water resources used	Regional	2017	Regional ministry
Water use intensity by economic activity	Not available		
Presence of faecal coli forms in freshwater	Regional	2015-2017	Regional ministry
Biological oxygen demand (bod) in water bodies	Ministry estimation		
Wastewater treatment	Regional	2011-2017	Regional ministry
Bathing water quality	Ministry estimation		

Source: UN,2007

The estimated amount of available water is 909.88 m^3/day, in 2012 241.45 m^3/day was used. Which equals to 26.54 % of available water. It gives an opportunity to conclude, that water is not a scarce resource in Tambov region (Ministry of natural resources and ecology Tambov region, 2018).

More than 72% of water is used for drinking and household purposes, for production and agriculture only 15% of water is used.

The industry and agriculture are not water intensive in Tambov region and the water stocks are sufficient (Ministry of natural resources and ecology Tambov region, 2018).

Presence of faecal coli forms in freshwater is the proportion of freshwater resources destined for potable supply containing concentrations of faecal coliforms which exceed the levels recommended in the World Health Organization (WHO) Guidelines for Drinking-water Quality (United Nations, 2007).

The conditions of water are regarded as stable; the main problems are the change of climate (warmer summer) and the burden of economic activities.

Table 4.17 Share of samples with unsatisfactory water quality in Tambov region

	2015	**2016**	**2017**	**2018**	**2019**
Sanitary-chemical analysis	5,9	7,05	4,75	4,4	5,7
Microbiological analysis	5,8	11,	17,1	12,97	19,8
Parasitological analysis	1,2	4,98	3,6	6,6	6,3

Source: Ministry of natural resources and ecology Tambov region, 2020

In the reports of ecological ministry of Tambov region there is data that some samples of water contain coli forms, but the levels are complying with the set norms (Ministry of natural resources and ecology Tambov region, 2020).

Biological oxygen demand (bod) in water bodies measures the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water (UN, 2007).

The oxygen conditions of main rivers of Tambov region is concluded to be satisfactory (Ministry of natural resources and ecology Tambov region, 2020, 2018).

Wastewater treatment is the proportion of wastewater that is treated, to reduce pollutants before being discharged to the environment, by level of treatment (primary, secondary, or tertiary).

In table 4.18 the statistic on wastewater purification is presented, and from this data a conclusion could be drawn that there is a clear problem with the quality of the treatment plants and it is usually explained by the old and inefficient (Ministry of natural resources and ecology Tambov region, 2018).

Table 4.18 Wastewater purification.

	Wastewater released into surface water						Wastewater released into groundwater
	All	Polluted			Clean by normative	Cleaned by normative	
		All	Without cleaning	Not enough cleaned			
2011	58,71	9,21	0,85	8,36	5,65	43,85	0,51
2012	57.08	41,76	0,32	41,44	6,34	8,98	0,45
2013	55,69	39,49	0,38	39,11	6,28	9,92	0,33
2014	53,49	37,95	0,42	37,53	7,04	8,5	0,26
2015	54	41,37	0,50	40,87	6,27	6,36	0,24
2016	52,42	40,77	0,48	40,29	6,7	4,95	0,21
2017	51,88	44,79	0,85	43,95	5,23	1,86	0,21

Source: Ministry of natural resources and ecology Tambov region, 2018

Bathing water quality is the indicator describes the changes over time in the quality of designated bathing waters (inland and marine) in terms of compliance with standards for microbiological parameters (total coliforms and faecal coliforms) and physicochemical parameters (mineral oils, surface-active substances, and phenols). Bathing water quality is reported to be in satisfactory conditions (Ministry of natural resources and ecology Tambov region, 2020, 2018).

4.2.5 Biodiversity

Biodiversity topic is covered by the indicators presented in table 4.19 (United Nations 2007).

Proportion of terrestrial area protected, total and by ecological region is defined as the share of terrestrial area that has been reserved by law or other effective means to protect part or the entire enclosed environment.

The area of protected regions is growing due to more awareness from the side of government, in 2007 there were 10700 ha of protected territories (0,3% of the total area) in 2019 the size of the protected territories has increased to 144800 ha (4,28% of the total area) (Ministry of natural resources and ecology Tambov region, 2020). The data available in Tambov region only can give an overview on the number and size of protected areas. but there is no reliable data how effectively the areas are managed.

Abundance of key species is an indicator, which uses estimates of population trends in selected species to represent changes in biodiversity, and the relative effectiveness of measures to maintain it. The indicator can be applied to individual species groups (e.g., birds, butterflies), or can be aggregated to incorporate several taxa (e.g., like the Living Planet Index), according to data availability and indicator applicability (United Nations 2007). The only dynamics, which is available is the data concerning hunting animals the changes in the population are controlled by hunting organisations.

Table 4.19 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Proportion of marine area protected	Not available		
Proportion of terrestrial area protected, total and by ecological region	Regional	2013-2019	Regional ministry
Management effectiveness of protected areas	Not available		
Area of selected key ecosystems	Not available		
Fragmentation of habitat	Not available		
Change in threat status of species	Not available		
Abundance of key species	Not available		
Abundance of invasive alien species	Not available		

Source: UN, 2007

The biodiversity topic is poorly covered by the statistical data. Biodiversity is not seen as a problem topic, for example in the report of the analytical centre of government of Russian Federation it is stated that Russia us a global environmental donor and the ecological footprint is not significant because up to 65 % of the area is presented with undisturbed landscapes with natural habitats of plants and animals (Analytical center of government of Russian Federation, 2016). The only two problems which highlighted in this report are the sustainable forest management and illegal trade of protected species.

4.2.6 Overview for ecological pillar of sustainability

It is difficult to assess the ecological pillar of sustainability as UNCSD framework includes 30 indicators which are covering ecological pillar of sustainability, only for 7 indicators the statistical data is available.

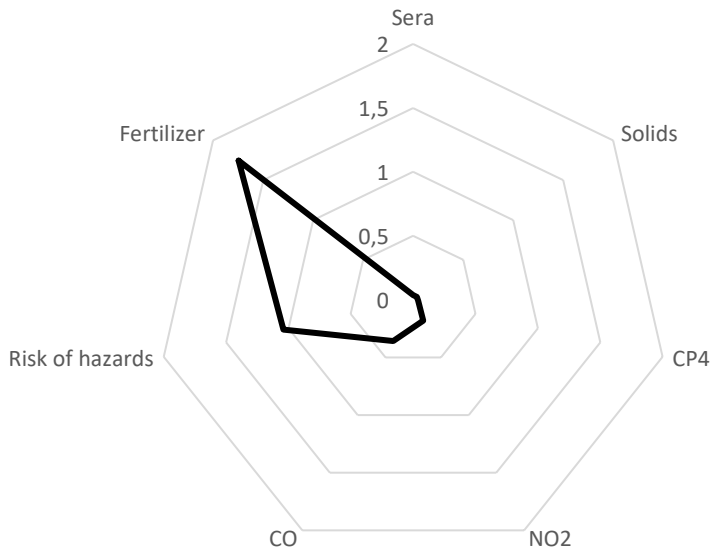
In the polygon 4.22 the overview of ecological indicators is presented. The most ecological indicators of Tambov region have lower level as the Russian level, the only indicator which is exceeding the Russian level is the fertilizer use efficiency, it is reasoned by the fact that the Tambov region is agriculturally intensive.

The level of risk of hazards is equal to the Russian level, other indicators are significantly lower than Russian level and do not reach 40 % of Russian level. According to the public organisation "Green Patrol" ranking the Tambov region is taking first place on the ecological ranking since 2012, the ranking indicators include environmental, industrial and ecological, socio-ecological index (Green patrol, 2018). Every index contains seven indicators, and the importance of the indicators is assessed by an expert group. The green patrol rating is the first attempt to gather environmental information into an index, but at the same time the assessment is not transparent, because the weighting of the indicator's importance is only based on expert evaluation.

The ecological theme is not fully covered with statistical data, there are some important indicators which are missing. For example, the data for greenhouse emissions and consumption of ozone depleting substances is not collected, also according to local expert an indicator "forest trees damaged by defoliation" is also relevant for Tambov region, but the data is not collected too. Mostly neglected topic is biodiversity, out of 8 indicators offered by the UNCSD framework only one is available. Unfortunately, the statistical data which is available is not enough for composite

indicator creation and it does not make sense to aggregate 7 indicators until more statistical data is available.

Fig. 4.20 Polygon for ecological pillar



Source: own illustration

In most scientific literature Tambov region is characterized as a region with favourable ecologic condition (Green patrol, 2018; Ministry of natural resources and ecology Tambov region, 2018; Regional'nyj informacionno-konsul'tacionnyj centr agropromyshlennogo kompleksa, 2019), but the ecological monitoring should be still performed and there is a clear need for collection of statistical data.

One of the main problems in the ecological monitoring is the non-transparency and complexity of the administrative structures, there are too many departments responsible for controlling and monitoring (Karsakov et al., 2018).

There are some attempts to reimburse the damage to environment with financial instruments, and according to the yearly reports of environmental ministry of Tambov region these reimbursements are regular, and the volume is growing every year (Ministry of natural resources and ecology Tambov region, 2018).

4.3 Economic sustainability

4.3.1 Economic development

Economic development theme is assessed with the help of the indicators presented in the table 4.20 (United Nations 2007).

Table 4.20 Summary table of data characteristics

Indicator	Availability		Source	Substitution
	Level	Period		
Gross domestic product per capita	Regional	2010-2018	Fedstat	
Investment share in gross domestic product	Regional	2011-2017	Fedstat	

Table 4.20 Summary table of data characteristics (continued)

Gross savings	Regional	2010-2015	Fedstat	
Adjusted net savings as percentage of GNI	Not available			
Inflation rate	Regional	2012-2020		
Debt to gross national income ratio Employment-to-population ratio	Regional	2008-2017	Fedstat	Unemployment rate
Vulnerable employment	Not available			
Labour productivity and unit labour cost	Regional	2011-2019	Fedstat	Index of labour productivity
Share of women in wage employment in the non-agricultural sector	Not available			
Number of internet users per population	Regional	2005-2017	Fedstat	
Fixed telephone lines per 100 population	Regional	2012-2017	Fedstat	
Mobile cellular telephone subscribers per 100 population	Regional	2012-2017	Fedstat	
Gross domestic expenditure on research and development as a percent of GDP	Country			
Tourism contribution to GDP	Not available			

Source: UN, 2007

GDP in central federal region is higher than Russian average, but in Tambov GDP is reaches maximum 67 % of average Russian level and only 52 % of central federal region (2015). GDP in Tambov region is repeating the trend of Russian and regional GDPs, it was growing in 2010-2014, then it had a decrease of 30% in 2015, in 2016 it has reached almost the same level as in 2015 and in 2017 it grew almost 20 %. If 83 regions of Russia are ranked according to their GDP level – Tambov region takes 49-54 positions.

Investment share in gross domestic product refers to the share of investment in total production (United Nations, 2007).

Investment share was fluctuating around 37 % in 2011-2018 in Tambov region. Interesting is the fact, that gross capital formation in Tambov region is higher than in Russia and central federal region and it is equal to 38,6%, Russian average in 2011-2018 was 20,9% and 16,4% in CFR (EMISS, 2019). In the national ratings on investment climate Tambov region took 12th position among all Russian regions in 2018, favourable investment climate is considered an undoubted advantage by the administration of the region (Administraciya Tambovskoj oblasti, 2019).

Gross savings is defined in national accounts as gross disposable income (i.e., gross national income plus the balance of current transfers with the rest of the world). If available, the alternative net savings, i.e., gross savings less capital depreciation, may provide superior information. Both gross and net savings may be expressed as rates, i.e., as gross (net) savings divided by gross (net) disposable income (United Nations, 2007).

In table 4.21 the gross savings are presented, unfortunately only data for 2010-2015 is available. The savings had stable growth in 2010-2013 (in Tambov region also in 2014), but then it had declined in 2015 and reached the lowest level in 6 years.

Table 4.21 Gross savings in USD

	2010	2011	2012	2013	2014	2015
RF	272687,7	329632,5	371136,1	414201,5	362031,9	235365,8
CFR	67255,0	80860,1	85759,2	100913,6	91877,9	62911,6
Tambov	1596,1	1818,0	2186,1	2599,9	2639,9	1851,8

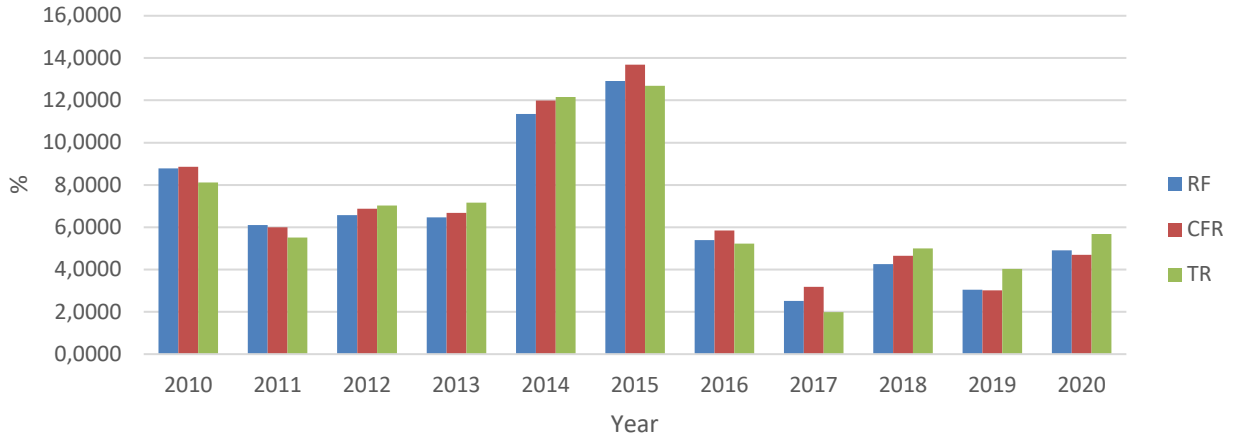
Source: EMISS, 2019a

Inflation rate is defined as the cost of living as measured by the annual percentage increase of the consumer price index (United Nations, 2007).

Source: EMISS, 2021

Overall trend of inflation rate for Tambov region repeats the development of Russian average level and the level in central federal region (EMISS, 2019). In 2017 the inflation rate reached the lowest level in the history of Russian federation. This level could be explained by the policy of Central Bank, continuous decrease of real incomes and high yields. In 2018 the inflation has reached planned level of 4 % (Interfax, 2019).

Fig. 4.21 Inflation rate



Debt to gross national income ratio can be defined as the total amount of outstanding debt issued by the general government divided by gross national income (United Nations, 2007). Data availability for this indicator is limited. There is information concerning the income and expenditure of regional budget. From one side in 3 out of 5 years regional budget had surplus, but the absolute size of it is lower than one-year deficit. It is a sign of budget instability.

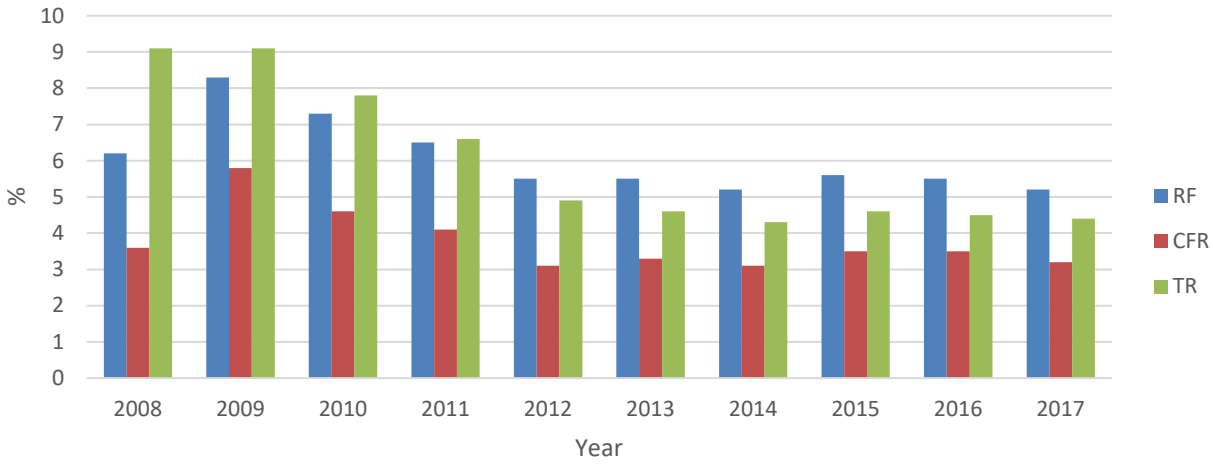
Table 4.22 Budget of Tambov region.

	Income, mil. Rub	Expenditure, mil. Rub	Deficit (-), surplus (+), mil. Rub
2005	17316	17228	86,9
2010	33781,1	34818,3	-1037,3
2015	57451,3	61013,1	-3561,8
2016	60631,3	62920,90	-2289,6
2017	58444,7	60966,9	-2522,2

Source: EMISS, 2019a

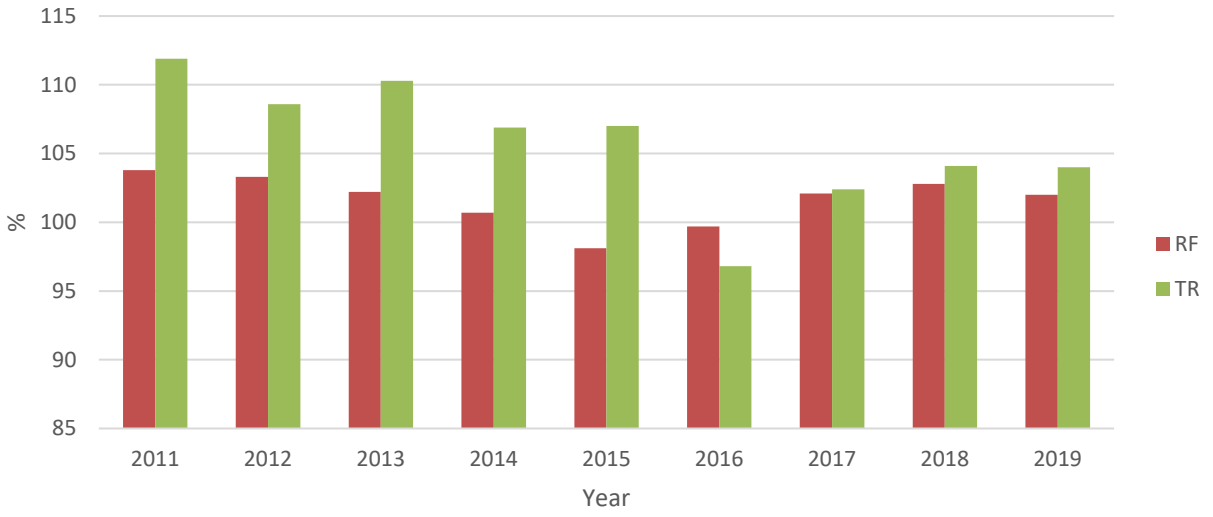
Employment-to-population ratio is defined as the proportion of a country's working-age population that is employed (United Nations, 2007).
In Tambov region employment to population ratio in 2014 was equal to 96 %, which was the highest rates in last six years. Nevertheless, this ratio was always higher than 90 %.
There was a decrease in the unemployment rates in 2009-2013, and since then the level of unemployment stays relatively stable. Official unemployment rates were in a range 4-5 % in last 6 years, but many scientists argue that it represents the reality, because the rates are calculated as a relation between officially registered unemployed people and economically active population (Kulikov and Kulikova, 2009).

Fig. 4.22 Unemployment rates.



Source: EMISS, 2019a
The problem groups are people younger than 29 years old and people of almost pension age. In the rural areas 61 % of this group are unemployed (EMISS, 2021).
Vulnerable employment is defined as the share of own-account workers and contributing family members in total employed people (United Nations, 2007). No official statistic for this indicator is available.
Labour productivity and unit labour cost is defined as output (in constant prices) per unit of labour. The indicator can be reported for the total economy as well as for different sectors (United Nations, 2007).

Fig. 4.23 Index of labour productivity



Source: EMISS, 2021

In federal statistic only index of labour productivity is available, it is showing a change in productivity in percent in relation to the previous year. The productivity rates on Russian level are more stable, the rates in Tambov region have more fluctuations and in 2011-2015 the trend was positive, and rates were exceeding 100 %, but in 2016 the rate dropped below 100. The productivity rate in 2015 was the highest among Russian regions (Analytical center of government of Russian Federation, 2017). The analytical centre of government of Russian Federation (2017) describes the trend of the labour productivity as unstable, this instability is explained by the sectoral structure of the economies of the constituent entities of the Russian Federation, the state of the material and technical base of the industries and the availability of workforce of the required qualifications.

At the same time such regional differences could be a consequence of insufficient attention of the heads of the constituent entities of the Russian Federation to the problem of increasing labour productivity and the lack of relevant practical actions (Analytical center of government of Russian Federation, 2017).

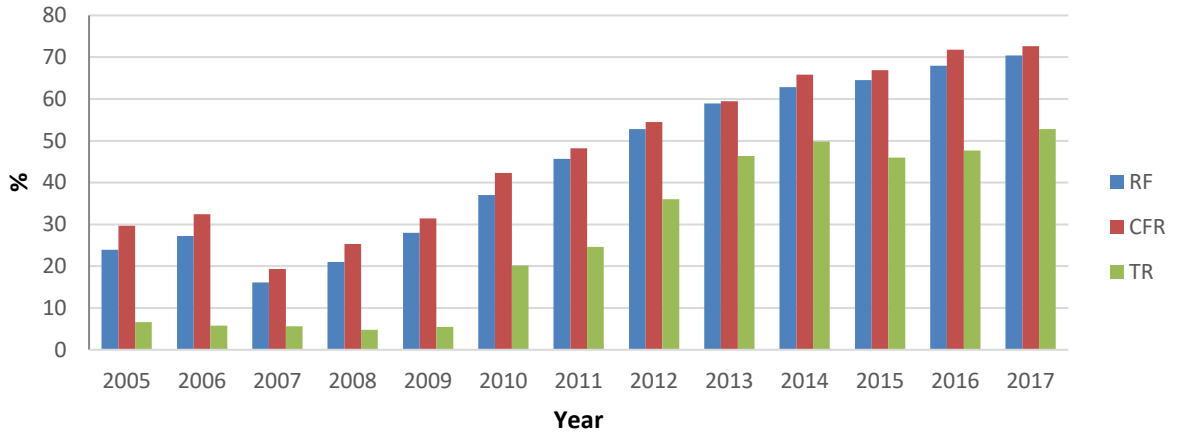
Share of women in wage employment in the non-agricultural sector is the share of female workers in wage employment in the non-agricultural sector expressed as a percentage of total wage employment in that same sector. The non-agricultural sector includes industry and services (United Nations, 2007).

This indicator is not very relevant for Russian condition, because labour markets are open to women and employment opportunities are relatively equal. But still some inequalities are existing, but they could be explained by the preserved elements of the patriarchal way of life, not the inequality of opportunities (Bedrickij, 2012).

The inequalities could be seen in the lower wages, despite of the fact that in last year's female wages are growing, average female wage was equal to 60,7% of male wage in 2005 and 72,6 % in 2015 (Bedrickij, 2012; Nikolaev et al., 2017). This difference could be partly explained by the unevenness of career positions and the fact that more women than men are working part-time (Nikolaev et al., 2017).

Number of Internet users per population is computed by first dividing the number of Internet users by total population, and then multiplying by 100 (United Nations, 2007). The share of households with internet access is significantly lower in Tambov region in comparison to average Russian level and CFR level. The share was steadily rising in 2009-2014 and then it stabilized on 50% level, Russian and CFR level was also rising but it had stabilized on 70 % level.

Fig. 4.24 Share of households with access to internet

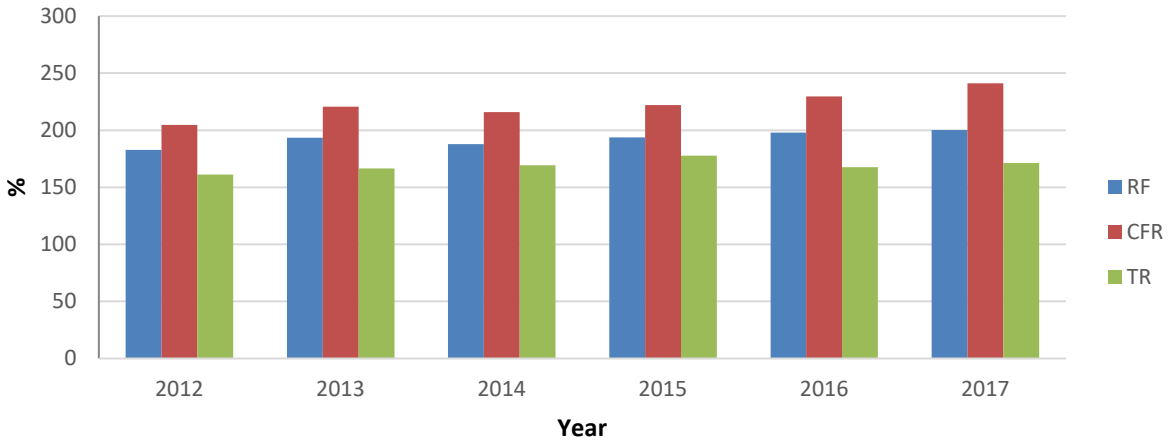


Source: EMISS, 2019a

Fixed telephone lines per 100 population is one of the broadest and most common measurements of the degree of telecommunication development in a country. Telecommunication is critical to

support sustainable development and is closely linked to social, economic, and institutional development (United Nations Commission on Sustainable Development (UNCSD), 2007).
The number of households with fixed telephone lines is constantly decreasing it is caused by cellular telephone accessibility. The decrease is more clearly seen on Russian level, than in Tambov region. Also, rural areas are switching to mobile communication more slowly (EMISS, 2021).
Mobile cellular telephone subscribers per 100 population is derived by dividing the number of mobile cellular subscribers by total population and multiplying by 100 (United Nations, 2007).

Fig. 4.25 Mobile cellular telephone lines per 100 population



Source: EMISS, 2019a
Availability of cellular phones is high and is growing every year and it is substituting the fixed telephone lines.
Gross domestic expenditure on research and development as a percent of gross domestic product is expressed as a percentage of Gross Domestic Product (GDP). Gross domestic expenditure on R&D (GERD) activities are defined as the total intramural expenditure on research and development performed on the national territory during a given period. This includes both current costs and capital expenditures (United Nations, 2007).
Data for this indicator is only available on Russian level, the share of expenditure equals 1,1 % of GDP in 2016 and it was stable in last 10 years (EMISS, 2019).
Tourism contribution to GDP is defined as the sum of the value added (at basic prices) generated by all industries in response to internal tourism consumption and the amount of net taxes on products and imports included within the value of this expenditure. The tourist contribution is not calculated separately for Tambov region. Data for this indicator is only available on Russian level, the share of contribution equals 3,4 % of GDP in 2016 and it is slowly growing in last 6 years (EMISS, 2019).
In 2012-2014 in Tambov region the number of tourists, number of tourist organisations and tourist contribution were growing. Despite of the fact that Tambov region has a touristic potential it takes insignificant position on the Russian tourist market (Fidorenko and Machalkin, 2016).

4.3.2 Consumptions and production patterns

Consumption and production pattern's theme is covered by the indicators presented in table 4.23 (UN, 2007).
Consumption and production pattern topics are poorly presented by statistical data in Russia, there are only few indicators for which data is collected and it is mostly on country level. It is interesting that in goal 12 in SDG is also not covered by statistical data and none of the indicators are planned to be collected.

Table 4.23 Summary table of data characteristics

Indicator	Availability		Source
	Level	Period	
Annual energy consumption, total and by main user category	Not available		
Share of renewable energy sources in total energy use	Country	2010-2016	Federal statistic
Intensity of energy use, total and by economic activity	Not available		
Generation of hazardous wastes	Regional	2010-2017	Federal statistic
Generation of waste	Regional	2010-2017	Federal statistic
Waste treatment and disposal			
Management of radioactive waste	Not available		
Modal split of passenger transport	Country	2010-2016	Federal statistic
Modal split of freight transport	Country	2010-2016	Federal statistic
Energy intensity of transport	Not available		

Source: UN, 2007

Share of renewable energy sources in total energy use. Renewable energy sources are divided into non-combustible (geothermal, hydro, solar, wind, tide, and wave) and combustible renewables and waste (biomass, animal products, municipal waste, and industrial waste). Non-renewables are fossil fuels (coal, crude oil, petroleum products, gas) and nuclear (United Nations, 2007). There is statistical data only on Russian level and the share of renewable sources was equal to 0,21 % in 2016 and 2017 (EMISS, 2019).

Generation of hazardous wastes is the total amount of hazardous wastes generated per year through industrial or other waste generating activities, according to the definition of hazardous waste as referred to in the Basel Convention and other related conventions (United Nations, 2007).There is data about generation of toxic waste, and the dynamic decreasing in last years (EMISS, 2019). This indicator needs more statistical data.

Generation of waste and disposal is the amount of all waste, both hazardous and non-hazardous, generated by selected main groups of industries or sectors of the economy, expressed per capita and per unit of value added (in US $) by economic activity (at constant prices) (United Nations, 2007).

Generation of waste is an important problem in Tambov region, every year more than 5 mil. m^3 waste is generated. The problem is that most of the waste is not recycled or reused, it is just stored. Another problem is illegal landfills, in 2017 there were 137 illegal landfills, but 83 of them were closed (Ministry of natural resources and ecology Tambov region, 2020). There are some initiatives for waste sorting, but it is still rudimentary (Ministry of natural resources and ecology Tambov region, 2018). The share of waste which is reused or recycle is still very low.

The main sources of waste generation in 2017 were livestock breeding complexes (Tambov Bacon LLC) and enterprises of the processing industry (Rusagro-Tambov sugar factories) (Ministry of natural resources and ecology Tambov region, 2018).

Modal split of passenger transport measures the share of each mode (passenger cars, buses and coaches, and trains) in total inland passenger transport, measured in passenger-km. The indicator provides information on the relative importance of different modes for passenger transport. The use of cars for passenger transportation is generally less energy efficient and has greater

environmental and social impacts, such as pollution, global warming as well as a higher accident rate, than mass transit (United Nations, 2007).

Table 4.24 Generation, use and disposal of hazardous waste (thousand tons)

	Generated	Used	Disposed
2005	1193,5	344,2	81,3
2010	808,1	252,2	54,0
2011	998,7	236,	64,6
2012	2625,4	1626,9	0,4
2013	3657,9	2304,0	0,3
2014	3883,2	2656,7	0,1
2015	4033,4	2826,8	0,06
2016	4385,2	3191,0	4,2
2017	5371,3	4560,0	4,6

Source: EMISS, 2019a

In last seven years the passenger intensity on buses was decreasing and it has declined from 29% to 22%, rail transportation share was also decreasing (from 29% to 22%) and at the same time air transportation share has increased from 30% to 46%. In 2015-2016 there was a shift of passengers form international to domestic flights due to the currency fluctuations, but in 2017 international flights started to grow again (Analytical center of government of Russian Federation, 2018). All other transportation types have less importance and they have remained stable.

Modal split of freight transport measures the share of each mode (road, rail, and inland waterways) in total inland freight transport, measured in ton-km (United Nations, 2007).

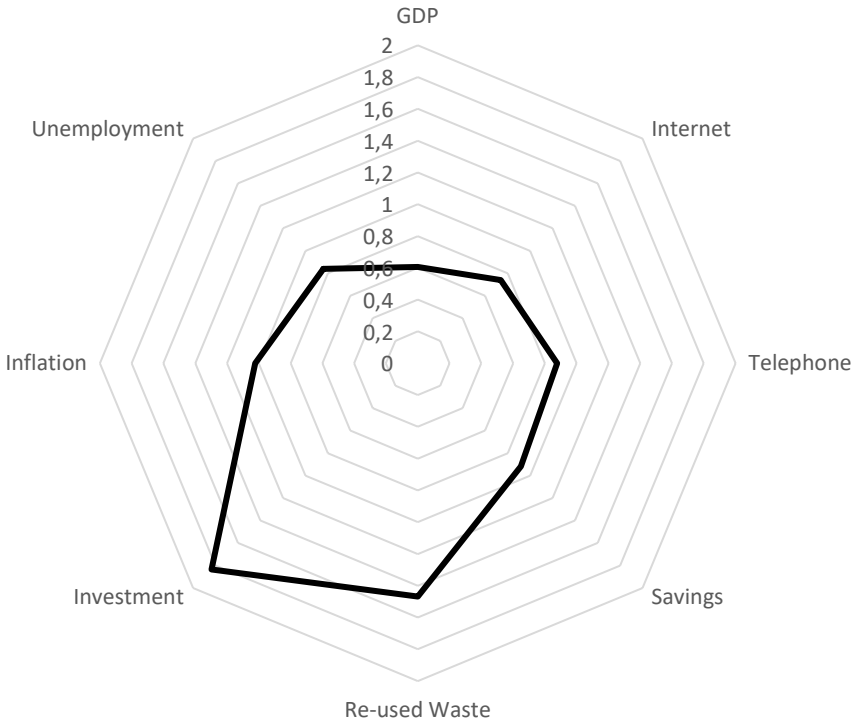
The split of freight transport has remained stable in 2010-2017 in Russia, 48 % takes pipeline transportation, 45 % railway transportation and 5 % automobile, all other types of transportation take remaining 3 % (EMISS, 2019). The statistics is only available on country level.

4.3.3 Overview for economic pillar of sustainability

In the figure 4.32 the polygon of economic pillar is presented. Tambov region´s indicators are exceeding average Russian level in indicators of re-used waste, investment share of GDP and inflation rate. But the indicators GDP is reaching only 60 % of the Russian level. Tambov regions is clearly exceeding Russian level of investment attractiveness and it is a clear strength of the region. Investment climate is considered as an advantage by the administration of the region (Administraciya Tambovskoj oblasti, 2019). At the same time Tambov region has lower accessibility of telephone lines and internet.

There are several indicators for which statistical data is missing, some of the statistical data is considered unreliable by Russian scientist. For example, unemployment rates are calculated as a relation between officially registered unemployed citizens and economically active population, and it is common that people do not register their unemployment status (Kulikov and Kulikova, 2009).

Fig. 4.26 Polygon for economic pillar



Source: own illustration

Such indicators as vulnerable employment and share of woman in wage employment are not covered by statistical data. Gender inequality is a controversial topic for Russia, from one side labour market is open for women, but from the other side there is a clear salary gap between men and women.

Another important indicator, for which statistical data is missing, is a share of expenditure on research and development, unfortunately statistics is only available for national level, but regional data, if collected, could be a source for important information for the sustainability assessment.

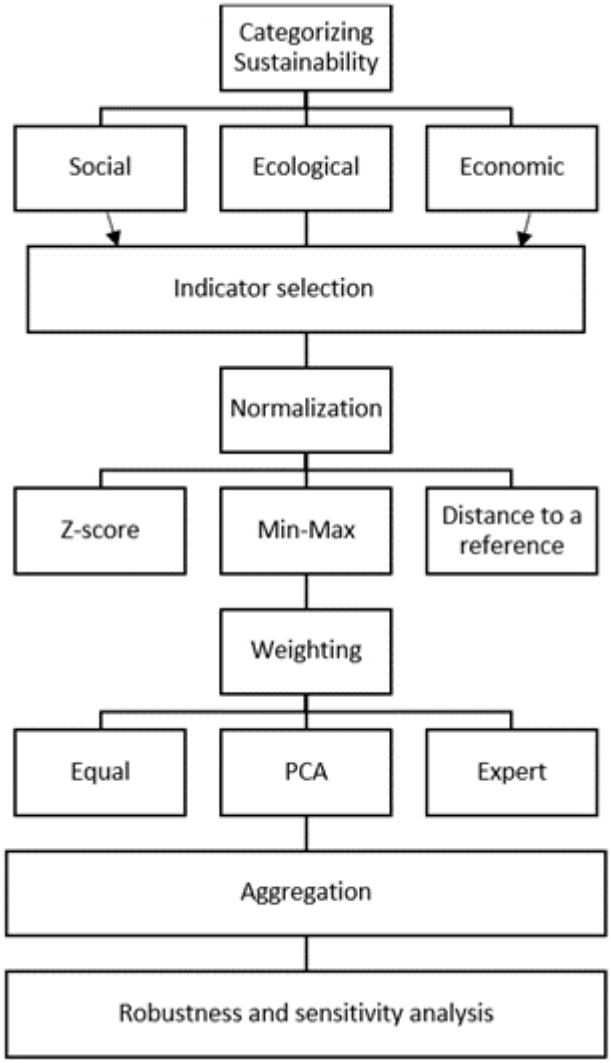
Consumptions and production pattern's theme is not fully covered, there are only two indicators which are available for regional level – generation of waste and generation of hazardous wastes. Data for such important indicators as intensity and structure of energy use is not collected and according to the SDGs the data is not planned to be collected.

4.4 Composite indicator

4.4.1 Composite indicator for the social pillar

The first step in selection of variables for the assessment of sustainability is the analysis of quality of available indicators. 31 indicators are covering poverty, health and well-being, education, and demographics topics. For 11 of indicators the data is not available, for 5 indicators a suitable substitution could be found (to substitute some of the indicators more than one indicator is needed). For the most of indicator the data is available for the period 2012-2016.

Fig. 4.27 Research design



Source: own illustration

31 indicators could be used for the creation of composite indicator. To find a suitable methodology for composite indicator creation different composite indicators will be compared. The difference in the composite indicators will be the normalisation techniques, weighting procedure, and indicator selection.

All the sub-indicators are gathered into one data set, and it is normalised with following techniques:

- z-scores with zero means and unit variance (z)
- re-scaling or min-max standardization (mm).

Following weight techniques will be used for indicator creation:

- equal weights
- weights extracted with help of PCA
- weights based on the expert interviews.

After weights of indicators were extracted with help of PCA, the indicators are compared to the equal weighting and the expert's opinion of indicators importance. Sub-indicators are aggregated with the method of weighted arithmetic mean.

Factor analysis is only possible when several prerequisites for the data are fulfilled. These preconditions are influencing the indicators selection. That is why it makes sense to divide the composite indicators in two groups, the first one will be an aggregation of all indicators, and the second group will be an aggregation of the sub-indicators which are fulfilling the preconditions for the factor analysis.

The next part of this chapter is covering the preliminary analysis and factor extraction for the PCA based weights.

4.4.2 Preliminary analysis

In this part of the thesis the preliminary analysis of the data for years 2012-2016 normalised with z-score technique is presented. For other datasets the same procedure is used. The datasets are analysed for correlation, both datasets are yielding same results. There are 31 sub-indicators covering following topics: poverty, governance, health and well-being of people, education, and demographics. If all sub-indicators are taken for factor analysis, it occurs that the dataset is not suitable for it. The determinant is too low and equals 7,447E-14 which means that there is a problem with multicollinearity.

Table 4.25 Item-Total Statistics

Deleted sub-indicator	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Income	34,016	0,623	0,784
Bath	35,736	0,464	0,800
Sew	36,055	0,436	0,803
Hot_wat	35,962	0,444	0,802
El_plat	35,758	0,462	0,800
Crime_s	35,851	0,454	0,801
Alco	34,151	0,611	0,786
Kindergarten	34,750	0,555	0,791
Edu_sat	38,048	0,263	0,819
Edu_non	35,122	0,520	0,795
Abort	36,148	0,428	0,804

Source: own calculation

On the base of correlation coefficients, the sub-indicators are regrouped into several sets, in each set the correlation coefficients between the variables are at least 0,3 and is not higher than 0,9. For example, the indicators characterizing bathing facilities and water availability are highly correlated.

The immunization indicators are highly correlated between each other and lack correlation with other indicators. Apart of the determinant value Cronbach-alpha coefficient should be not less than 0,7. For 26 indicator Cronbach-alpha equals 0,32 which is not suitable. To reach an appropriate level of this coefficient the indicators with negative corrected item-total correlation are deleted.
Field (2009) is recommending excluding the indicators which corrected item total correlation is lower than 0,3, because it indicates bad internal consistency and identifies such indicators as potential problem.
11 indicators are retained for the analysis and Cronbach-alpha coefficient equals 0,814. In the table 4.25 item-total statistics for the indicators is presented.

Table 4.26 Correlation matrix

	Income	**Bath**	**Sew**	**Hot_wat**	**El_plat**	**Crime_s**	**Alco**	**Kinder-garten**	**Edu_non**	**Edu_sat**	**Abort**
Income	1,00	0,40	0,31	0,37	0,41	0,40	0,47	0,41	0,27	0,38	0,20
Bath	0,40	1,00	0,82	0,84	0,16	0,05	0,13	0,15	0,00	0,21	-0,10
Sew	0,31	0,82	1,00	0,78	0,14	0,04	0,09	0,20	0,04	0,15	-0,06
Hot_wat	0,37	0,84	0,78	1,00	0,13	0,04	0,12	0,19	0,00	0,24	-0,06
El_plat	0,41	0,16	0,14	0,13	1,00	0,52	0,32	0,16	0,29	0,33	0,30
Crime_s	0,40	0,05	0,04	0,04	0,52	1,00	0,30	0,44	0,19	0,21	0,52
Alco	0,47	0,13	0,09	0,12	0,32	0,30	1,00	0,59	0,28	0,67	0,60
Kindergarten	0,41	0,15	0,20	0,19	0,16	0,44	0,59	1,00	0,21	0,35	0,56
Edu_sat	0,27	0,00	0,04	0,00	0,29	0,19	0,28	0,21	1,00	0,15	0,20
Edu_non	0,38	0,21	0,15	0,24	0,33	0,21	0,67	0,35	0,15	1,00	0,40
Abort	0,20	-0,10	-0,06	-0,06	0,30	0,52	0,60	0,56	0,20	0,40	1,00

Source: own calculation
For the PCA analysis following indicators are included:

- Cash income (average per capita) (income) (positive polarity)
- Share of housing equipped with bathing facilities (bath) (positive polarity)
- Share of housing equipped with sewerage (sew) (positive polarity)
- Share of housing with hot water (hot_wat) (positive polarity)
- Share of housing equipped with electric stoves (el_plat) (positive polarity)
- Number of recorded serious crimes per 100,000 population (crime_s) (negative polarity)
- Share of patients with a first-ever established diagnosis of alcoholism (alco) (negative polarity)
- Availability of places in pre-school educational organisation for children of pre-school age (kindergarten) (positive polarity)
- Share of population satisfied with educational services (edu_sat) (positive polarity)
- Share of children of school age who are out of school (edu_non) (negative polarity)
- Abortion rate (Abort) (negative polarity)

In the table 4.26 the correlation coefficients are presented. Determinant is equal to 0,001, which is suitable for factor analysis and there is no problem with multicollinearity of the dataset. All the indicators are correlating well and there is no need to consider eliminating any indicators at this stage.
Kaiser-Meyer-Olkin measure is equal to 0,731, which is good according to Field (2009) and the data can be used for factor analysis. Bartlett`s measure of sphericity is significant, indicating that

correlations between items were sufficiently large for PCA and therefore factor analysis is appropriate. SPSS is also calculating the residuals, which are computed between observed and reproduced correlations, in this case there 41 % of nonredundant residuals which is also acceptable (Field, 2009).

4.1.6.2 Factor extraction

A principal component analysis was conducted on 11 items with oblique rotation (oblimin), it was run to obtain eigenvalues for each component in the data.

Table 4.27 Components overview.

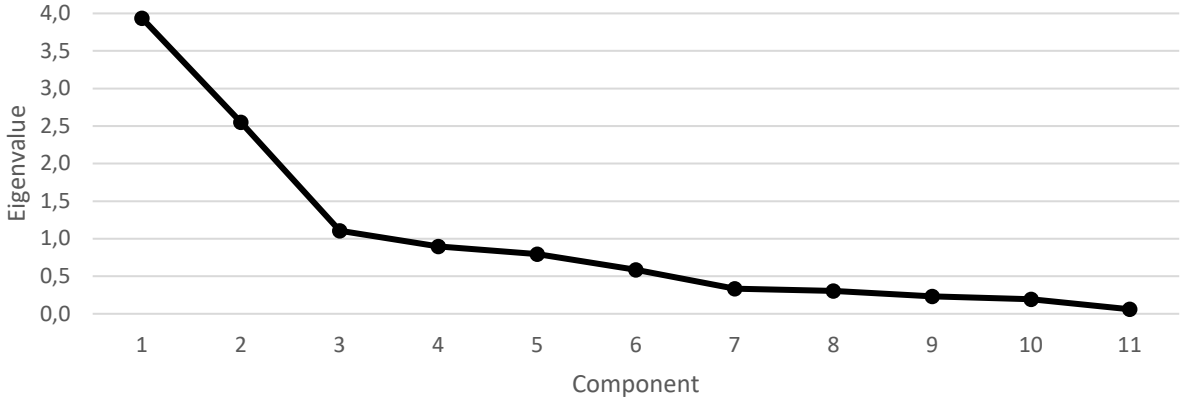
	Initial eigenvalues			Rotation Sums of squared loadings		
Components	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3,94	35,78	35,78	3,94	35,78	35,78
2	2,55	23,21	58,99	2,55	23,21	58,99
3	1,11	10,07	69,06	1,11	10,07	69,06
4	0,90	8,17	77,22			
5	0,80	7,24	84,46			
6	0,59	5,32	89,78			
7	0,33	3,04	92,82			
8	0,31	2,78	95,60			
9	0,23	2,10	97,70			
10	0,19	1,75	99,45			
11	0,06	0,55	100,00			

Source: own calculation

In the table 4.27 the eigenvalues associated with each linear component before extraction are presented. Before extraction, there were eleven linear components within the data set. The eigenvalue associated with each component represent the variance explained by the component and it is displayed in terms of percentage of variance explained. There are three components with eigenvalues higher that 1 which are explaining 69 % of variance. Last three columns display the rotation sum of squared loadings – the eigenvalues of the components after rotation. Rotation has the effect of optimizing the component structure and one consequence for these data that the relative importance of the components is equalized (Field, 2009).

Figure 4.28 is a graphical presentation of the eigenvalues in descending order. The first component explains the maximum variance in all sub-indicators – eigenvalue of 3,31. The second and third components also have eigenvalue greater than 1 and it will be retained in the analysis. The scree plot is showing inflexions that justify retaining three first components.

Fig. 4.28 Scree plot



Source: own illustration

Then all the components with eigenvalues greater than 1 are extracted. In this case, there are three components. The unrotated solution is difficult to interpret because the components are inter-related, for such cases Field (2009) advises to use oblique rotation. In the table 4.28 the factor loadings are presented.

Table 4.28 Factor loading based on principal components

	Factor loadings			**Squared factor loading (scaled to unity sum)**		
	1	**2**	**3**	**1**	**2**	**3**
Income	0,05	0,14	0,22	0,02	0,05	**0,12**
Bath	0,00	0,94	0,00	0,00	**0,32**	0,00
Sew	0,00	0,87	0,00	0,00	**0,30**	0,00
Hot_wat	0,00	0,83	0,00	0,00	**0,29**	0,00
El_plat	0,01	0,01	0,73	0,00	0,00	**0,39**
Crime_s	0,03	0,01	0,50	0,01	0,00	**0,27**
Alco	0,81	0,00	0,00	**0,30**	0,00	0,00
Kindergarten	0,58	0,00	0,00	**0,22**	0,00	0,00
Edu_sat	0,00	0,00	0,38	0,00	0,00	**0,21**
Edu_non	0,58	0,02	0,01	**0,22**	0,01	0,00
Abort	0,58	0,07	0,02	**0,22**	0,03	0,01
Explained variance	3,46	3,08	2,72			
Weights of factors in CI	0,37	0,33	0,29			

Source: own calculation

The last step deals with the construction of the weights from the matrix of factor loadings after rotation. The approach is to group individual indicators into intermediate composites according to their factor loadings. First component is a mix of educational and health indicators, the second one

covers income and house facilities and the third one is including the rest of indicators. The three intermediate composites are aggregated by assigning a weight to each of them equal to the proportion of the explained variance.
The same procedure is repeated for all the data sets.

4.1.6.3 Robustness and sensitivity

As was already mentioned during the composite indicator creation there are many decisions which should be taken by researcher and those decisions are leading to uncertainties.

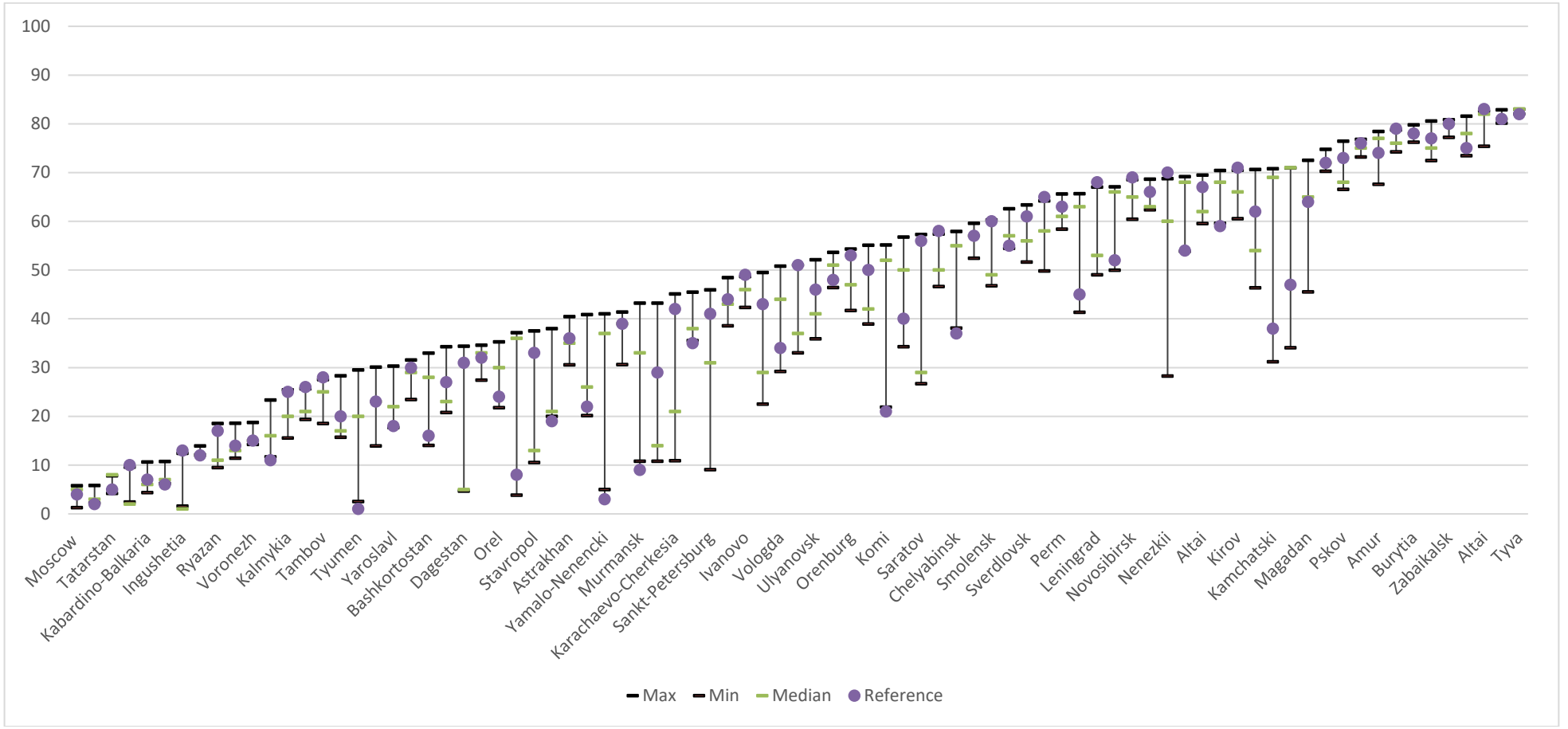
Table 4.29 Uncertainty factors

Input factor	Definition	PDF	Range
X_1	Weighting scheme	Uniform	[0,1], where [0,0.33] – equal, [0.33,0.66] – expert, [0.66,1] – PCA
X_2	Indicator choice	Uniform	[0,1], where [0,0,5] all indicators, [0.5,1] PCA indicators
X_3	Data selection	Uniform	[0,1], where [0,0,5] data from 2012-2016 and [0.5,1] data from 2016
X_4	Normalisation method	Uniform	[0,1], where [0,0,5] Z-scores and [0.5,1] Minmax normalisation

Source: own elaboration

The sensitivity analysis is giving an opportunity to analyse how the variation in composite indicator and region ranks derive from different sources of variation in the assumptions.
The uncertain input factors for the composite indicator are weighting scheme, indicator choice and normalization method. In the table 4.29 the uncertainty factors with PDF are presented.
In the figure 4.36 the results from the Monte Carlo simulation for the 83 regions are presented. The graph presents the "median" performance across all 10000 simulations as a summary measure of all uncertainty factors, it is displayed as a 5th and 95th confidence interval for each region. The composite indicator based on the average data from years 2012-2016 and aggregated with equal weights is taken as a reference.
In this case the confidence intervals are relatively narrow, it means that uncertainty factors have moderate influence on the region´s ranks. Only for 10 region the median rank equals to the reference rank.
The widest confidence intervals for the median rank are estimated for 5 regions (more than 40 positions). A very high volatility is found for Nenezkii (45 positions), Kamchatskii (44 positions), Sakhalin (41 positions) and regions. The volatility of those regions is due to the combined effect of uncertainties. Despite these concerns, for most of the regions, namely for 71 regions the confidence interval is narrow enough (less than 30 positions) to allow for reliable interference on those ranks. Hence for those regions the rank can be used as an indication of where the policies aimed to support social sustainability work well and where remedial action is needed.
Figure 4.29 shows the sensitivity analysis based on the first-order indices for central federal and North-West regions, the regions are ordered in ascending order of the rank shifts.
These shifts were non-intentional, but they were inherent in the methodological choices in the composite indicator construction, while uncertainty analysis brings them into light.

Fig. 4.29 Confidence interval of social CI

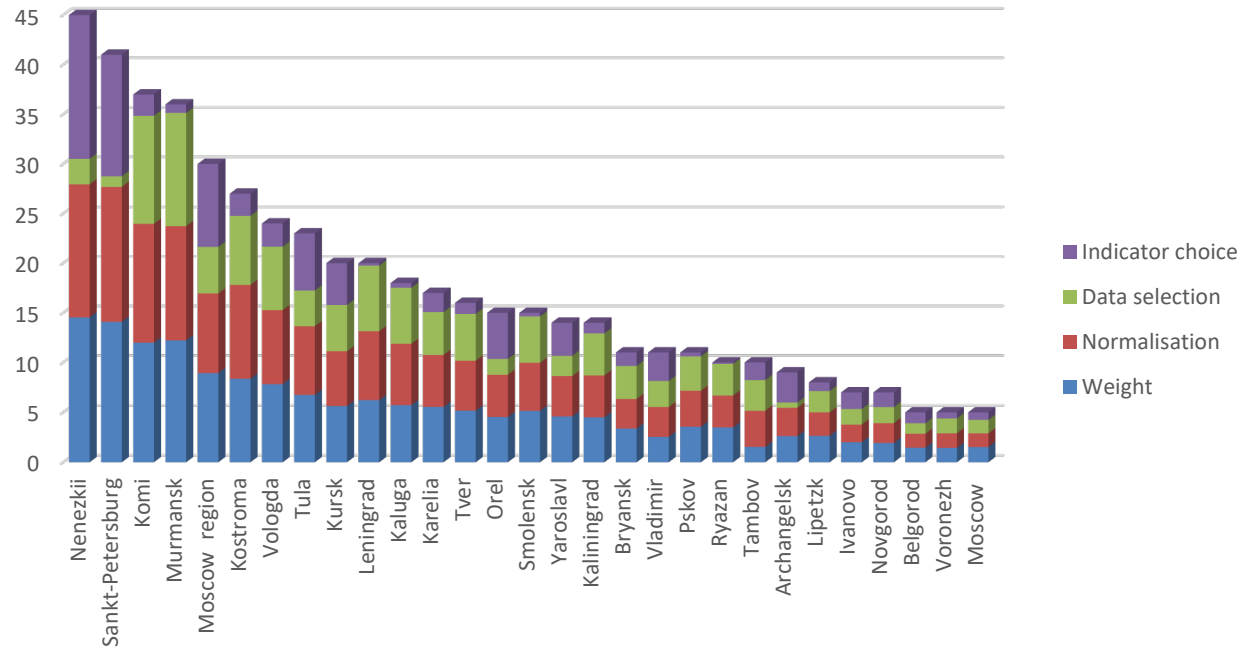


Source: own illustration

The graph is showing the median (green mark), the corresponding 5th and 95th percentiles of the empirical distribution of the simulated ranks (violet mark for reference CI) for 83 regions. Uncertain input factors: weighting, normalization, and data selection schemes. Regions are ordered according to the maximum indicator rank.

Complementary to the uncertainty analysis, a sensitivity analysis makes it possible to assess the impact of a modelling scenario in the composite indicator.

Fig. 4.30 Sensitivity measures of CI



Source: own illustration

According to the graph normalization and weight´s schemes are influencing the rank of the region more significantly as data selection, but there are some exceptions. For example, Nenezkii and Saint-Petersburg regions has the highest rank shift which is highly influenced by the indicator choice.

Although the different scenarios produce relatively different rankings compared to each other, the Spearman rank correlation between the different composite indicators and the median is higher than 0,95. However, certain regions are more sensitive than others in the methodological choices and hence their ranks need to be treated with caution when such ranks are used to formulate policy statements.

While the composite indicators are reliable for most of the regions analysed (74 out of 83), for the remaining regions the composite indicators need not be treated as particularly sensitive to the methodological assumptions in the indicator development. However, the overall indicator provides a reliable picture of the situation at the global level (high degree of correlation between the simulated median ranking and the reference ranking).

The selection of the weighting procedure is of paramount importance, because when the PCA procedure is used it is changing not only the weights of the sub-indicators, but also the sub-indicators choice, as not all the indicators could be appropriate for PCA.

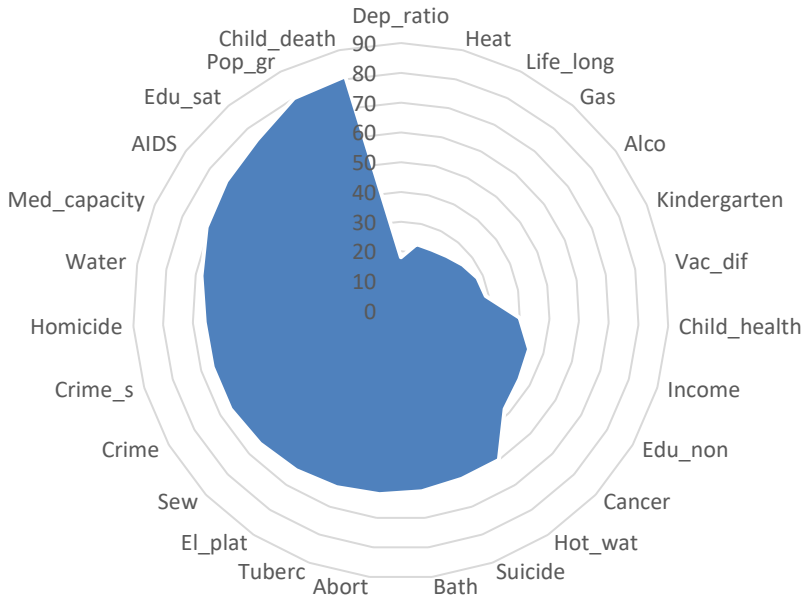
4.4.3 Tambov region ranking

The next step of the analysis is the decomposition of the indicators, it will be done on the example of Tambov region. The highest rank of Tambov region equals 18, lowest is 28. The rank of Tambov region is not very sensitive to the changes in uncertainty factors. The rank of Tambov region is higher when it is determined on the base of PCA composite indicator.

Median rank in both cases is similar and according to both CI group Tambov region could be classified into a group of “leader regions”. This fact is not surprising as after the regional analysis

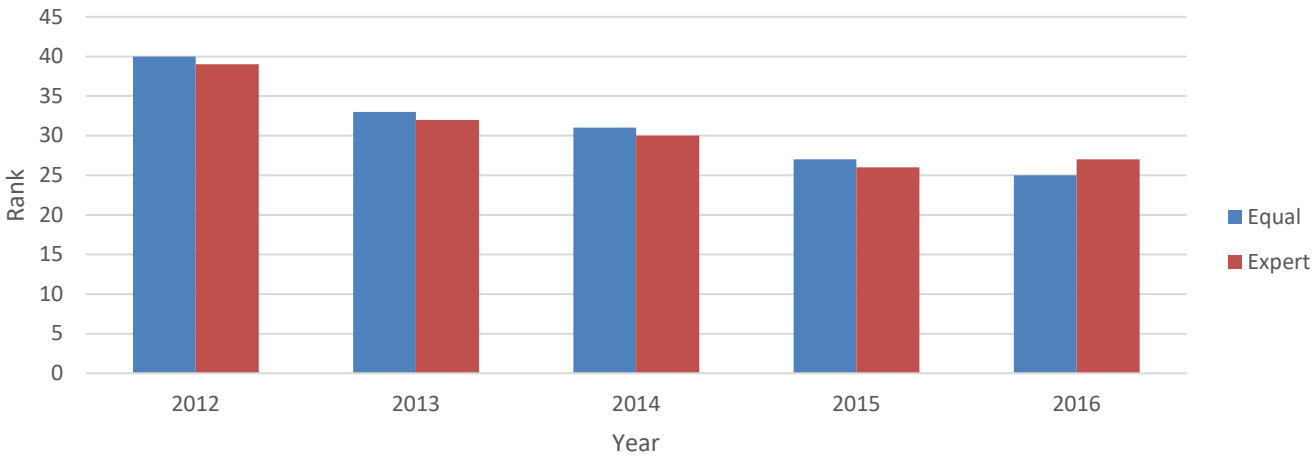
there was an impression that Tambov region had higher rates in most of the indicators, and just few indicators were lower than Russian average level.
In the figure 4.31 a spider diagram is presented; it is showing the rank of the Tambov region according to the different sub-indicators. The highest rank has the indicator of dependency ratio, which means that the share of working population is higher in Tambov region, which is a strength, but at the same time Tambov region has one of the lowest levels of population growth and relatively high child death rates.

Fig. 4.31 Spider diagram ranking of sub-indicators for Tambov region



Source: own illustration
It is interesting that the left side of the graph, where the indicators with the lower ranking are gathered, is mostly the indicators from the demographics, health, and governance topics. At the same time poverty indicators are mostly located in the right side of the graph, which means that strengths of the region are located mostly in poverty theme.
In the figure 4.32 the dynamics of the rank change is presented. For comparison the composite indicators created on the base of all indicators with equal and expert weights.

Fig. 4.32 Rank change for Tambov region



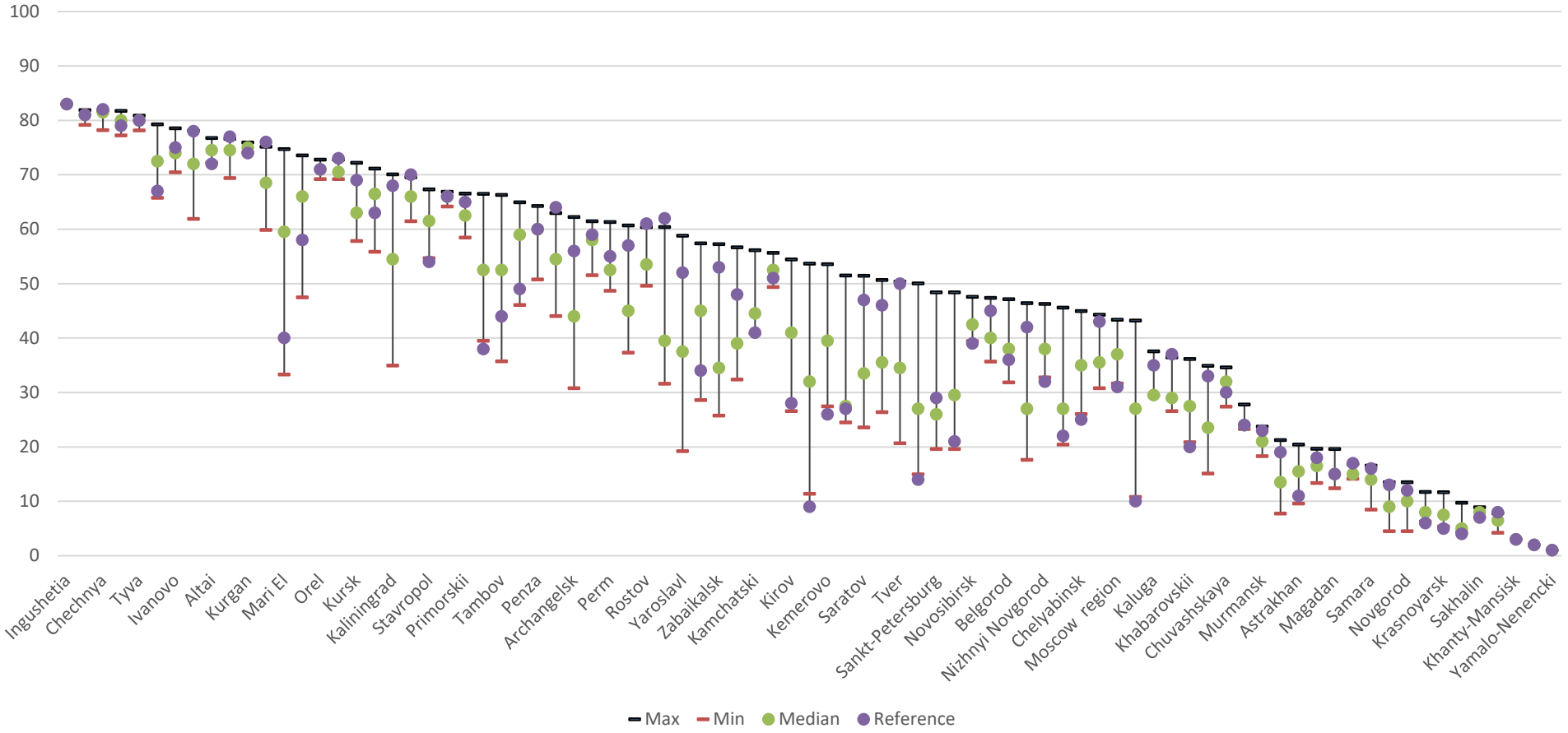
Source: own illustration

In 2012-2015 there was a stable rank growth which stopped in 2016 and the rank of equal weighting CI was lower than expert weighting during all years except 2016. The rank of Tambov region has changed from position 40-39 (Equal-Expert) in 2012 to position 25-27 (Equal-Expert) in 2016. This dynamic is showing a positive development of the region in the social sphere in comparison with other regions.
In the main analysis the average data from 2012-2016 and data from 2016 was used, and it could be seen that by averaging the data the information is lost. For example, in 2012 the Tambov region is on 40 position, when on average in 2012-2016 Tambov lowest rank was 28. For monitoring purposes, it makes sense to use yearly indicators and average indicators from several years should be used with precaution. When the indicators for separate years are analysed the Tambov region rank is moving to leader´s group, but a clear conclusion, that Tambov region is one of a leading regions during last 5 year, could not be drawn.

4.4.4 Composite indicator for economic pillar

The statistical data is available for 7 economic indicators: GDP, investment share in GDP, inflation rate, unemployment rate, share of households with access to internet, share of recycled waste, amount of electricity generated. The preliminary analysis is showing that these indicators are not suitable for PCA. Composite indicator is created with equal and expert weighting, with 2 different normalization techniques and 2 rows of data from years 2012-2016 and form 2016.
In the figure 4.33 the confidence intervals of the composite indicators are presented. The composite indicator based on the average data from years 2012-2016 and aggregated with equal weights and normalised with z-score procedure is taken as a reference. The confidence intervals are relatively narrow, it means that uncertainty factors have moderate influence on the region´s ranks.
There are only three regions which´s confidence interval is wider than 40 positions – Leningrad region (47), Mari-El (46) and Yaroslavl (44). For most of the regions, namely for 64 regions the confidence interval is narrow enough (less than 30 positions) to allow for reliable interference on those ranks.
It is interesting to see, that the regions with highest and lowest ranking are less volatile. For example, for the top 10 regions and for the 10 regions with the lowest ranks the rank shift is less than 10 positions, and in several cases, it equals 0.
Figure 4.41 shows the sensitivity analysis based on the first-order indices for central federal and North-West regions, the regions are ordered in ascending order of the rank shifts.
From the graph a conclusion could be made that the variation in region´s rank is mostly caused by weight and normalization procedure. There are just few regions where data selection is playing an important role.
The Spearman rank correlation between the different composite indicators and the median is higher than 0,95, which is confirming the reliability of the CI.
Economic rank of Tambov region is lying between 34 and 68 positions. The rank has middle positions and when CI is decomposed it could be seen that investment, employment and inflation have the highest ranks, the rest of the sub-indicators have lower ranks and Tambov region is in a group of “laggards” regions.

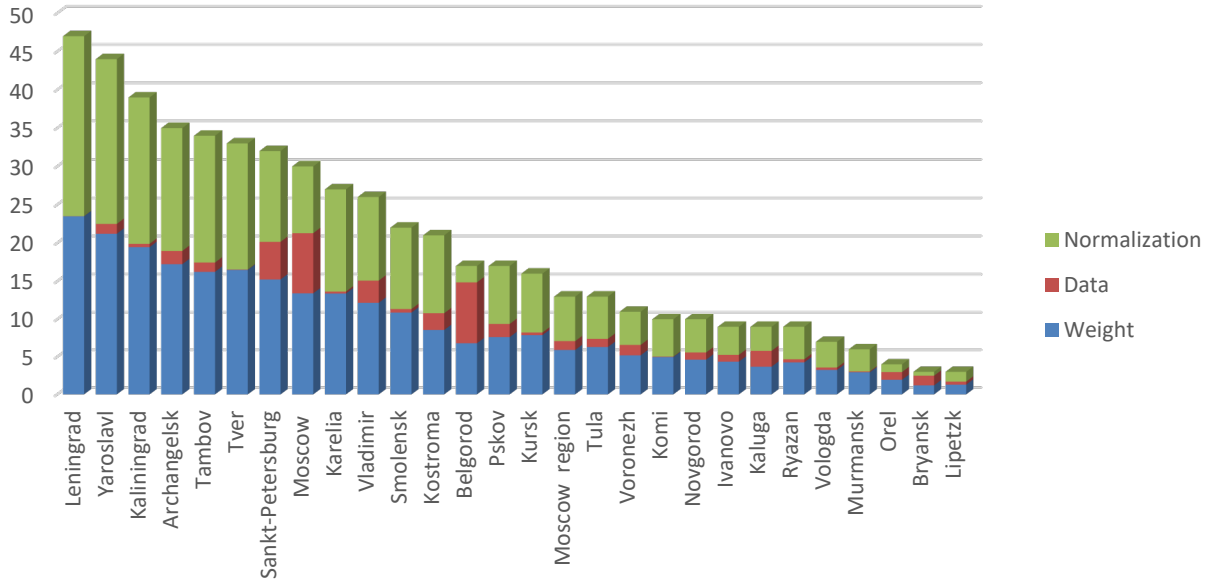
Fig. 4.33 Confidence interval of economic CI



Source: own illustration

The graph is showing the median (green mark), the corresponding 5th and 95th percentiles of the empirical distribution of the simulated ranks (violet mark for reference CI) for 83 regions. Uncertain input factors: weighting, normalization, and data selection schemes. Regions are ordered according to the maximum indicator rank

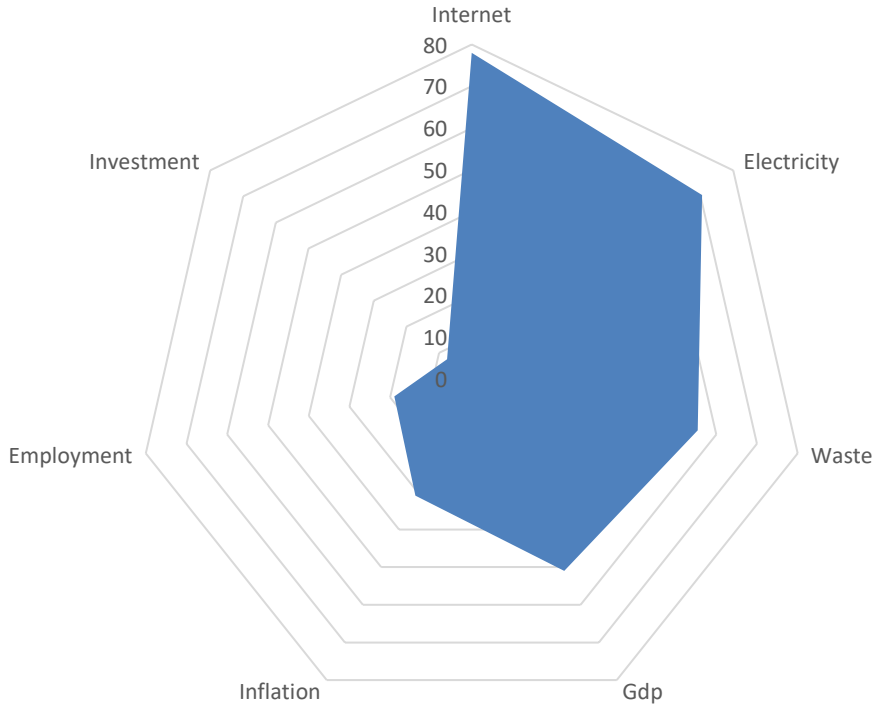
Fig. 4.34 Sensitivity measures of economic CI



Source: own illustration

Composite indicator is reflecting a similar level of economic development as in regional assessment. The investment attractiveness and unemployment levels are the strengths of the region. Nevertheless, for economic theme the amount of sub-indicator is clearly insufficient and there is a need to collect more data for a better monitoring possibility.

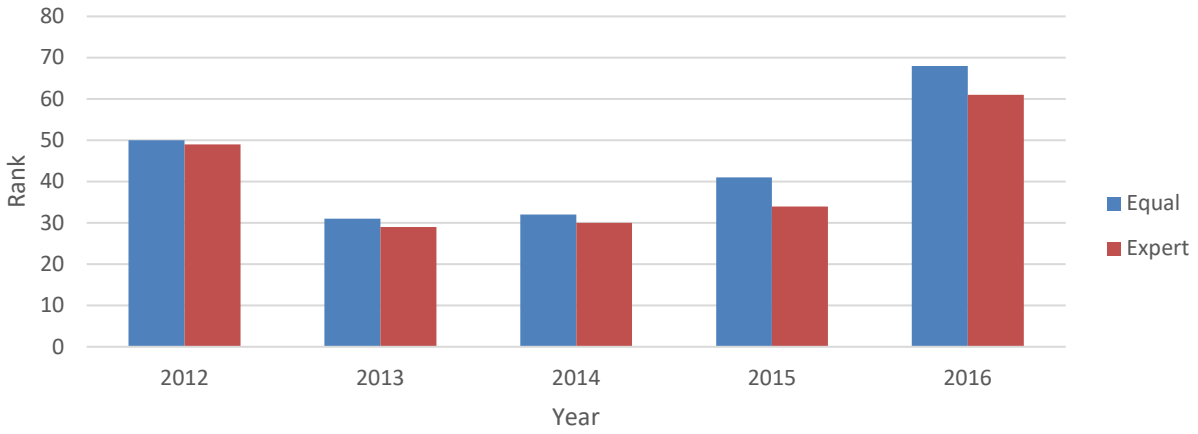
Fig. 4.35 Polygon for economic sub-indicators



Source: own illustration

In the figure 4.36 the dynamics of the rank change is presented. For comparison, the composite indicators created on the base of all indicators with equal and expert weights.

Fig. 4.36 Rank change for Tambov region



Source: own illustration

In 2013 and 2014 Tambov´s rank has risen in comparison to 2012, but in 2015 and 2016 the rank got worse to the level lower than in 2012, the rank of equal weighting CI was lower than expert weighting during all years. The rank of Tambov region has changed from position 49-50 (Equal-Expert) in 2012 to position 68-61 (Equal-Expert) in 2016. This dynamic is showing a negative development in the economic sphere of the region in comparison with other regions, and it is important to come back to the initial data find out what have caused this shift in the ranking. In the table 4.30 the ranks of sub-indicators are presented.

Table 4.30 Rank shift of sub-indicators

	GDP	Waste	Electricity	Internet	Employment	Inflation	Investment
2012	59	30	73	72	19	60	10
2013	54	30	72	71	18	62	7
2014	49	26	72	75	18	68	8
2015	49	23	71	79	19	47	6
2016	52	75	70	80	18	46	7

Source: own elaboration

In the sub-indicators GDP, amount of electricity generated, employment rate, inflation rate and investment share in GDP Tambov region had improved its performance but decrease in the rank of sub-indicators share of households with access to internet, share of recycled waste, and amount of electricity generated was so high that it led to the decrease of the composite indicator.

As was already discussed composite indicators are summarizing information and are useful instruments to simplify the communication of the statistical data to decision-makers, but the information loss is unavoidable, and it is not enough just to put the sub-indicators together, it is important to investigate the reasons which are behind the rank changes.

In the case of composite indicator created for the assessment of economic development of Tambov region during this research, it is also conforming the fact that composite indicators are useful tools, and they are fulfilling the aim of showing the direction of regional development.

4.5 SWOT analysis

One of the aims of this work was to use the assessment methodologies to find out the strengths, weaknesses, opportunities, and threats for the sustainability of development.

In the tables 4.31 and 4.32 the results of SWOT analysis are presented. The SWOT analysis was performed separately for social, economic, and ecological pillar of sustainability.

Table 4.31 Strengths and weaknesses

Strengths	*Weaknesses*
Social: • High education level of citizens • High accessibility of medical services • Low criminal level • High level of sanitation services **Environmental:** • Favourable climatic condition • Favourable environmental conditions • Fertile black soils • Rich water resources **Economic:** • Favourable geographic location • Favourable investment climate • Low inflation rates	**Social:** • Insufficient number of places in preschool educational institutions • Low-income level • High share of alcoholic diseased • Low rank on life expectancy • Worn-out utility networks **Environmental:** • Lack of monitoring of environment • Neglection of ecological problems • Low priority on ecological measures • Low awareness of environmental problems **Economic:** • Insufficient supply of prepared investment sites • Low share of innovative products • Insufficient financial opportunities for local large business

Source: own elaboration

Tambov region has many strengths, but one of the most important is the human potential, the citizens of Tambov region are highly educated, but it also causing the risk of high human capital flight. To use this strength of the region there is a need for governmental programs, which could make it attractive for young specialists to stay in Tambov region.

Another strength of the region is high accessibility of medical services, but at the same time there is high share of citizens with alcoholic disease and life expectancy has a low rank among Russian regions. Here a problem could lie in a low health awareness of citizens, there is a need for program to motivate citizens for regular health check-ups and for a healthier way of living.

According to collected statistical data Tambov region has a relatively high-level sanitation facilities, but there is also information that the utility networks are worn-out and there is high possibility of accidents (Administraciya Tambovskoj oblasti, 2018).

In the environmental sphere Tambov region has the potential due to favourable climatic and environmental conditions. The region is rich in land, forest, and water resources, but it lacks sustainable management and monitoring system. There is a need to move the focus on the environmental problems, which are often neglected.

Important issue which needs a special attention is the waste management, there is an urgent need for waste treatment plants. Citizen's awareness of waste problems and of environmental problems is an important issue. Environmental education is missing in Tambov region as well as in Russia.

Tambov region has a favourable geographic location, and this position could be used to attract investors and to develop new industries. According to the collected data Tambov region has a favourable investment climate, but overall recession in Russian economy is posing a serious threat to economic sustainability of the region. Local investors do not have sufficient financial opportunities for business development, and it is often a problem, that there is a lack of prepared investment sites and it is increasing the terms of implementation and costs of projects (Administraciya Tambovskoj oblasti, 2018).

Table 4.32 Opportunities and threats

Opportunities	*Threats*
Social: • Programs to increase attractiveness of the region for young professionals • Programs for rising health awareness • Growth of active and creative young citizens • Implementation of utility infrastructure programs **Environmental:** • Collection of statistical data to monitor environmental conditions • Programs for waste management • Opportunity for waste treatment facilities building **Economic:** • Effective use of the geographical location of the region in the Central European part of the Russian Federation to attract investors and develop new industries • Efficient use of resources • Organization of new industries in agriculture, manufacturing, including processing agricultural products	**Social:** • Human capital flight • Ageing of human capital (high death rates, low birth rates) • Low awareness of citizens of health condition • Danger of accidents on worn-out utility networks. **Environmental:** • Increased environmental impact • Siltation of water • Loss of agricultural land and reduction of soil fertility • Surface water pollution **Economic:** • Economic recession in Russia • Instability of the economic environment • Lack of qualified personnel ready to work in the real sector

Source: own elaboration

As was already mentioned that the human potential is a strength of the region, but beside the migration of the qualified worker, there is problem of qualification losses and progressive reluctance of the intention to work in the real economy sectors. This reluctance is posing a threat to the economic development and to the implementation of investment projects, that require the involvement of qualified labour resources.

4.6 Conclusions

Russia is still at the very beginning of the transition to sustainable development, although the sustainability concept was adopted in the governmental strategical documents already in 1996, the implementation is still not fully elaborated (Lanshina et al., 2019).

One of the aims of this work was to explore the possibilities of assessing sustainability in Russian Federation, by applying chosen methodologies to one of the Russian regions. One of the main questions was to consider possible ways to measure progress towards sustainable development. To achieve this goal, literature research was first carried out and, based on this analysis, it was decided to use a set of indicators to assess the sustainability of the region.

The first part of the chapter 4 was devoted to the analysis of regional development in the last 5-10 years, the research was carried out as a preparation for the creation of composite indicators. The UNCSD set was analysed for suitability, relevancy, and data availability. Also available statistical data was reviewed to find possible substitutions for the indicators which are included into the UNCSD set but are not present in the official Russian statistics.

This analysis showed that with such assessment it is possible to determine strengths and weaknesses of the region.

In case of Tambov region its strengths lie in human potential, the health indicators are on a slightly higher level than average Russian level – the level of diseases (AIDS, Tuberculosis) are lower than in Russia on average, life expectancy is on an average Russian level. From the other side income indicator is only 0,8 of average level and it is a clear limiting factor.
In the ecological pillar the indicators, for which the statistical data is available, are showing lower values comparing to average Russian level, all except fertilizer use efficiency which is caused by the intensive agriculture in the region. The ecological situation in the region could be described as favourable according to the data available, but there is a need to complete the statistics, as many of the indicators are not collected.
The economic assessment of the region is showing that Tambov has a favourable investment climate and high level of re-used waste, at the same time the inflation rate has exceeded average Russian level in the assessed years and GDP was only 60% of Russian level. The investment climate is a clear potential of the region, and it should be used to improve the economic situation, but the economic situation in the region could not be fully assessed due to missing indicators.
There is on-going work in collection of statistical data, Russian statistical agency has acknowledged the importance of data collection according to the SDGs (Analytical center of government of Russian Federation, 2020), not all of the goals are covered even on the national level, but the work is initiated and there is hope that in few years the statistics will be available for analysis. Therefore, it is important to elaborate methods which could be used to analyse collected data. To follow this aim after regional analysis a procedure of composite indicator creation on the base of available statistical data was tested.
The composite indicator and the ranking of the regions are complementing the regional assessment very well. Just from the regional assessment a decision-maker could be overwhelmed and confused with all the figures and graphs, but when the regional assessment is accompanied by composite indicator the decision-maker is becoming a clear signal, that the region is in a group of leading regions or on the contrary is in laggards' group. When only composite indicator is used, after calculating the rank of the region it will be still necessary to decompose the indicator to understand the reasons behind a certain rank. That is why, the composite indicators should be accompanied by the regional assessment.
At present moment there is no monitoring mechanism at the federal district level in Russian Federation. It is clear that successful organization of a national and regional monitoring system will facilitate the adoption of timely objective management decisions that will ensure the transition of regions to sustainable development and support future sustainability (Galkina, 2013; Lanshina et al., 2019), and this research confirms the fact that there is a need to develop sustainability criteria and choose a system of indicators of sustainable development in Russian Federation. As such a system could become a very useful tool for decision-makers.
During the literature research it became clear that the construction of composite indicators is not a straightforward process and when a composite indicator for a such complex phenomenon as sustainability is created, it is not making the process easier (Mazziotta and Pareto, 2016). Sustainability is a concept with multidimensional nature, and it requires a definition of a set of individual indicators to be properly assessed. Due to the broad spectrum of topics which sustainability is covering – the list of indicators becomes very long, and the individual indicators are quite often summarized into a composite index.
The first problem in composite indicator creation is the choice of sub-indicators. There are obvious issues such as data availability and data quality. During this research the statistical data provided by federal statistical agency and different ministries was used, as one of the aims of this work was to assess the possibilities of composite indicator use for sustainability assessment the question of the data quality provided by Russian official agencies was beyond the scope of this research, but the research was clearly limited by the data availability.
The question of data availability is a clear limiting factor for the indicator´s use, especially in the case when the work of the statistical departments, which are making the decision which data to

collect, is not coordinated with the work of departments which are making the assessment of the data. To assess the progress towards sustainability there is a need for comparison over at least several last years, and if statistical departments are constantly changing the list of the indicators for collection, it makes such a comparison almost impossible.
Another issue is that set of indicators which are supposed to measure sustainability are too common and the sets do not permit the inclusion of specific characteristics or discourses that are important for a certain region (Balmford et al., 2019). Zeijl-Rozema et al. (2011) have offered to compare region´s performance to its regional potential, but a shortcoming of this method that regions setting lower potentials will have a false sense of achievement.
Inclusion or exclusion of an indicator could lead to significant rank changes and indicators choice is often influences by the data availability. Therefore, in order to obtain valid and reliable results, it is essential to support the choice of the set of individual indicators with an appropriate theoretical framework (Mazziotta and Pareto, 2016).
During the research the UN framework was used, and the original framework was adopted to the Russian conditions. Because some of the indicators are irrelevant, for some indicators the data is not accessible, or the data quality is not acceptable. In case of Russia it is difficult to make a unified indicator´s framework, because Russia is a federative country and there are 85 federal subjects, which are very different and there will be indicators which are relevant for one region and are irrelevant for another region (Constitution of Russian Federation, 2020). Apart from the division in federal subjects there is a division into federal districts in Russia, and during the research this division was used, and it makes sense to create such a framework for each federal district, it will make the composite indicators comparable, and it will limit the data loss due to the differences between regions. This is the area where scientific research is needed, a theoretical framework of sustainability indicator should be elaborated for Russian conditions.
Composite indicator cannot be fully objective, that is why it is important that the construction process is fully transparent and repeatable. The first important step is to make the selection process of sub-indicators as transparent as possible; it is not an easy task as the frameworks offered by different institutions are not corresponding with the statistical data which is available. The person or the institution creating a composite index should justify the choice of substitution for an unavailable index or exclusion of a sub-indicator.
When the UN framework is used to assess sustainability in Russia, out of 81 indicators for 37 the statistical data is available on the regional level, 14 for social pillar of sustainability, 13 for ecology and 10 for economic. The indicators used for this research cover 46% of all the UNCSD set across Russian regions, the coverage is uneven across the aspects of sustainability and the incomplete indicator coverage may lead to misleading conclusions.
As was already mentioned Russia has adopted the sustainability development goals and hopefully the missing statistics will be collected and not only on the national level and hopefully the work of the statistical agency will be coordinated with the work of assessment and monitoring departments.
During the research three different weighting techniques were compared equal, expert and PCA weighting. The equal weighting procedure is the easiest one, the workload is minimal, but it is highly bond to the theoretical framework, and there are still open questions such as “which sub-indicators should be included” and “how to make sure that the indicators is reflecting the phenomena”. For example the UN framework includes an indicator “proportion of population using an improved sanitation facility”, there is no statistical data in Russian databases, but there is statistical data on the share of household with modern plumbing, bathing facilities, sewerage and hot water supply; and the question is should all of this indicators be included into the composite indicator or should all of the data covering sanitation be aggregated into composite index and then used for composite indicator. Equal weighting could only be used in case of well elaborated theoretical framework which is tailored for the creation of such a composite indicator and still there is a need to make the correlation analysis to avoid duplication of the data with highly correlated components.

Expert weighting could be an option for creation of composite indicators, but in the case of sustainability assessment the main issue of these technique is how to make sure that the expert´s evaluation is objective. The list of sub-indicators is very long and such method as budget allocation is hardly applicable because it is easy to lose an overview. During the research the experts from the Tambov region were asked to set the weights of the sub-indicators and the results of the expert´s weighting was almost identical with the equal weighting. The participation of the experts is necessary in the theoretical framework development, as they could determine which indicators should be included into the framework and which are not relevant, but with such a long list of sub-indicators the expert´s weighting is not the most suitable technique.

PCA weighting is completely determined by sample data (Bo and Woo, 2008) and it makes the composite indicator created with the PCA weighting more objective, but it makes the comparison difficult between different years. Equal weighting indicators are more suitable for comparison between different periods. Another problem of PCA is the workload, it is not comparable with equal weighting.

The results of the comparison of different composite indicators showed that some of the regions were not markedly affected by the choice of methods, it was mostly regions which were taking highest or lowest positions. Tambov region showed higher ranking with the PCA weighting, but with all the weighting procedures the region was in a leader´s group for social assessment and middle-performing group for economic assessment.

Nevertheless, the equal weighting as well as PCA weighting have shown robust results according to the sensitivity analysis and composite indicators created with both of this weighting techniques could give a policymaker an understanding about strength and weakness of a region and which areas of development need special attention to reach sustainability.

One of the aims of this dissertation were to develop a procedure for policymakers and to test the applicability of different methodological approaches. The result of this work has shown that composite indicators together with regional assessment on the base of sustainability indicators are the tools that could support policymakers in sustainability decision-making.

Nevertheless, there are several limiting factors which should be considered. First, there is a problem with missing statistical data in the field of sustainable development and lack of coordination with work of statistical agencies, which are constantly changing the lists of collected data and are adding and deleting groups of indicators, which should be collected. Second, composite indicator creation is resource and time-consuming, and it needs trained professionals. Thirdly, even in the case when a data is used correctly there are opportunities for manipulation due to complex construction procedure and many subjective decisions.

In Russia a governmental structure to monitor and assess the development, and to coordinate the work of different departments is missing and those problems will not be solved until a national strategy for reaching SDG is not only presented as concepts “on paper” but is implemented.

Sustainability education in Russia

During the research of sustainability assessment several interviews with representatives of local administration were performed, during the interviews apart from the questions concerning the weights of indicators the questions concerning the sustainability as a concept were discussed. After the interviews it became clear that there is a lack of understanding of the sustainability at the local administration´s level.

On the one hand, the topic of sustainability is present in many state documents (concepts, strategies, decrees), on the other hand, there are problems with understanding these terms among employees working directly with these programs and concepts. Therefore, the aim of this part of the study is to understand what role education plays in closing this gap.

As mentioned above, Russia already has sprouts of education in the field of sustainable development – there are specialized master's programs and individual disciplines, and it is interesting to investigate the education for sustainability and educational response to global sustainability problems through the perspective of agricultural universities staff in Russia.

Following research questions were formulated regarding this problem:

- How are the sustainability topics integrated into education?
- What are the incentives for the integration of sustainability?
- How the integration of sustainability could be strengthened?
- What barriers are standing in the way of the integration?

Firstly, the literature research was performed. The results of the literature research are presented in the chapter 2.7. The main statements after the literature research were following:

- There is presence of the sustainability concept in the official documents, but many researchers admit the lack of implementation
- There are some examples of the integration of sustainability into study process as master programmes
- There is a lack of educational programs with sustainability majors
- There is some evidence that sustainability education has transformed from the ecological education, and it is often confused with ecological education
- There are problems with interpretation of the term sustainability, and neglection of the concept´s complexity.

To further investigate the sustainability education in Russia 16 interviews were performed with the representatives of 8 Russian agricultural Universities. The interviews were semi-structured and included following topic:

- Integration of the sustainability theme on different levels of education (master and bachelor) and across different majors
- Interpretation of the concept of sustainability and inclusion of different aspects (economic, social, and ecological)
- Possibilities for teachers training and life-long learning
- Coverage of the competencies important for education for sustainability
- Sustainability awareness in everyday life
- Possible recommendations for improvement.

The interviews were performed in July-August 2020, the interviews were transcribed verbatim, and the results of the evaluation and interpretation are presented in the next sections.

5.1 Evaluation of the expert interviews

5.1.1 Integration of the sustainability topics into education

The first topic which was discussed with the interviewees was the integration of sustainability topic into education. 10 interviewees were representative of 4 universities which had a running master program with a major in sustainable rural development.

Table 5.1 Integration of sustainability topics in education

	Economic faculty		**Other faculties**	
	Bachelor	**Master**	**Bachelor**	**Master**
Study program	0	4	0	0
Specialized courses	2	0	1	3
Topics in other courses	6	4	7	5

Source: own elaboration

In the table 5.1 an overview of the integration of the sustainability topics into education. 4 out of 8 universities representatives of which has participated in the interviews has a specialised master program in sustainable rural development. This master program is usually a part of study program of economic or management faculties, and there are differences in integration of sustainability topics between economic and other faculties.

After this master program was launched 2 out of 4 universities have integrated specialised courses into bachelor program of economic and other faculties. In two other universities the sustainability on the bachelor level is presented as topics in other courses in all faculties. Michurinsk State Agrarian University and Buryat State Agricultural Academy have introduced specialised sustainability courses, the courses are usually offered as elective disciplines, and sustainability topics are more exposed to the master students. In Buryat State Agricultural Academy this course in sustainable rural development is also integrated into bachelor study program of other faculties. In Russian State Agrarian University in Moscow there is a specialized course “Ecological foundations of sustainable development” which is a part of curriculum of ecological majors, in other universities the specialised courses for sustainable development are offered only for economic or management majors.

Moscow State University of Geodesy and Cartography has also introduced a specialized master module with a focus on sustainable development, this master module was a result of EU Project GRETERE “Green Terra Development: EU policy and practice”. This project was implemented in 2018-2021 and during the interviews with the representatives of the university apart from this master module the sustainability was present only as a topic in other courses, but there is no specialized course which was integrated in other majors. This module was taught in the framework of "Architecture and Urbanism" and "Real Estate Management and Territory Development" majors.

There are several problems which occur in the sustainability integration, first sustainability education in researched universities in Russia is limited to the sustainable rural development, the understanding that concept of sustainability is concerning not only rural areas is not there. Some of the interviewees were confused by the questions regarding sustainability not in a context of rural development and they stated that there is no need to integrate sustainability into other majors as this issue only concerns economic and management majors.

Some of the experts also expressed concerns that it is not advisable to introduce this topic at the undergraduate level, because students would not be mature and would not be able to adequately perceive the information, but nevertheless, most experts were inclined to believe that there is a need

for a specialized course, and it is necessary to strengthen integration of sustainability topics at the bachelor level.
Also, experts are stating that the concept of sustainability on the bachelor level is only touched superficially. Even in the bachelor program, where specialised courses are available, it is often the case that the courses are offered as elective disciplines. Only students who are doing specialised master's degree are aware of the sustainability concept.

5.1.2 Labour market demand

The next section of the interview was devoted to the demand of the labour market. The experts were questioned if there is a communicated demand from enterprises or governmental bodies and organisations, and possible jobs for the graduates of the sustainable rural development master program were discussed.
As the master program which was launched after SARUD project is a part of economic or management faculty the most popular possible job named was an administrational job at the ministries or local administrations. The universities which have participated in the SARUD project have performed a labour market check before launching the master program. This check contained interviews with local representative of the administrations and ministries. The representatives of the Omsk agrarian University admitted that the representatives of the administrations and of agricultural enterprises agreed that there is a need for such specialists, but there was no formed request from the market and no initiative from them.
In most local and regional administration there is a department which is responsible for the development of rural territories, but this department is responsible for data collection, process analytics and monitoring of the federal programs, but they show no request for young professionals with knowledge in sustainable development. Nevertheless, some of the experts admitted that they are cases when regional administrations are requesting help with the work on the concepts and strategies of sustainable development. In this situation, it is possible that introduction of the master program in sustainable development overtook the demand from the labour market.
Experts also admit that very few organizations are submitting sustainability reports, but it is possible that it will become more popular and demand for specialist with knowledge in sustainability areas will grow.

5.1.3 Development of the sustainability education

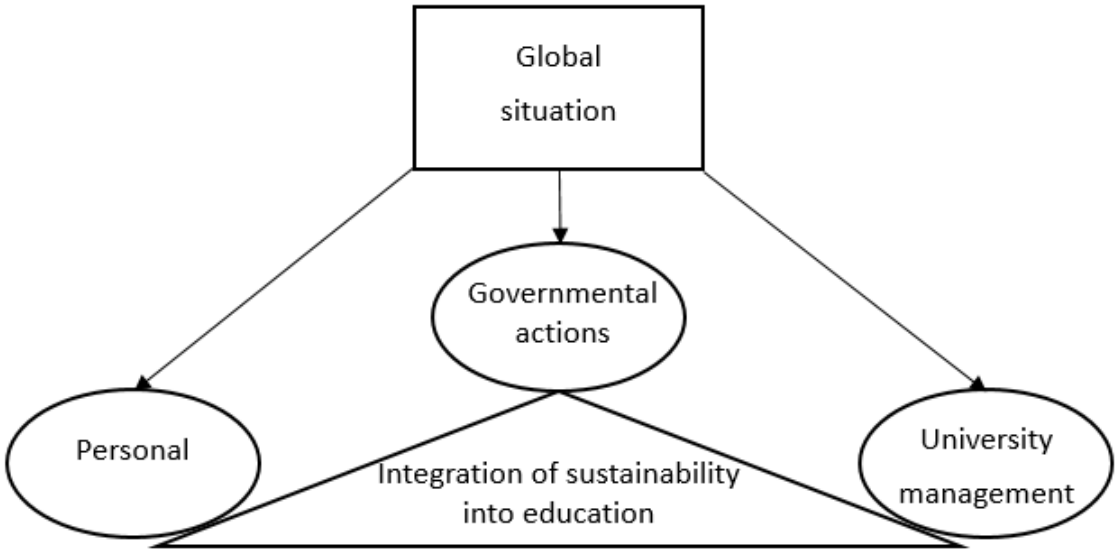
After the literature research one of the assumptions was a statement that education for sustainability has transformed from ecological education and in many spheres, it is still substituted with ecological education.
Integration of the sustainability into the education was started with the governmental actions. When sustainability concept was added to the Federal State educational standard of basic general education, there were stated, that one of the planned personal educational learning outcomes should be the formation of ecological culture, which consists of the environmental awareness, as well as gaining experience in ecologically oriented reflective-evaluative and practical activities in life situations (Kondakova and Kuznecova, 2008).
There was a clear ecological focus in this statement added to the federal educational standard, but at the same time government was launching several rural development programs with the aims of sustainable development of rural territories. And those programs had definite social bias and they were focusing on the infrastructural development of the territories.
There are several factors which have influenced the formation of the education for sustainability in Russia, and on the example of agricultural universities it could be seen that statement that sustainability education has originated from ecological education is not completely true at least in agricultural universities.

The regional development is usually a topic which is the centre of the research in economic faculties, and as most interviewees were representatives of the economic faculties, they mostly admit that economic development had always played and is still playing the major role.
In agricultural universities the term sustainability came from governmental development programs, those aspects included all aspects of sustainability, but ecological aspect was getting the least attention. Regional development is closely related to the agricultural production, and which is supported and stimulated by the state with the main aim to increase capacity, especially in recent years in the context of sanctions and import substitution.
In some universities, experts noted that the integration of sustainability topics began with environmental disciplines, such differences are maybe since in some universities the integration began earlier and was caused either by participation in European projects or by personal initiative. Such an example is a Russian State Agrarian University in Moscow, where the Faculty of Ecology has been studying the topic of sustainability for more than 20 years, and representatives of environmental disciplines were at the origins of integration. In other universities, the integration came from the side of economic disciplines such as "Agricultural economics" or "Development of rural areas", in them, under the influence of state policy, the topics of sustainability were integrated.
Continuing the questions if the sustainability had route in ecological education next section of the interviews were devoted to the questions if there is a bias towards one of the aspects of the sustainability or if one of the sustainability aspects is regarded as more important.
Here the opinions of experts were diverse and highly dependent on the expert's background and experience. Experts admit that bias towards one of the aspects is connected to the financing of the university institutions and to the personal interests of the teachers, as the educational standards give a certain grade of flexibility in curriculum, the institutions are trying to integrate their courses into the study plan without considering the importance of all the aspects.
As was already mentioned, the economic aspect of the development is quite often considered as more important, and none of the interviewees mentioned, that economic aspect is neglected in the studies. Ecologic and social aspects are often neglected, or they do not get enough attention according to the expert´s opinion. It is interesting that when the sustainable development is discussed on a political level it is often admitted that the ecological side of development is neglected, but Ilin et al. (2017) is admitting that in the sphere of sustainable education the ecological pillar prevails, but the situation with agricultural universities is different, because sustainability topics are integrated through courses with major in rural development and in those courses the focus lies on economic development.
But in one aspect the experts from the universities which have a running master program in sustainable rural development were unite, they are trying to incorporate the concept of sustainability into the education, and they are trying to highlight the importance of all the aspects for sustainable development.

5.1.4 Driving forces of the integration

As one of the aims of the research was not only to investigate how the sustainability topics are integrated, but also to elaborate recommendations for better integration it is important to answer the question: "Where the driving force for the integration is coming from?"
Experts have admitted four main sources of integration of the sustainability into study curriculum, the driving forces are presented in the figure 5.1. The main force which was admitted by 11 out of 16 experts was the personal initiative and interest of the teaching staff, next important factor is the decision on the higher level – governmental or on the level of different ministries, the third factor is the managerial decisions of the university administrations and heads of the responsible institutes.

Fig. 5.1 Driving forces of integration



Source: own elaboration

All these three factors are influenced by the global situation. Global situation includes research of the world scientific community, cases of best-practices and especially strong influence have different educational projects, which are offering experience exchange and training for teachers and students. The results of these projects are successful integration of sustainability topics into education and rising of sustainability awareness.

The governmental influence could be seen in the federal educational standards, but as was already mentioned the standards are setting the competencies, which students should master, but universities themselves are taking the decision how exactly those competencies will be acquired. Sustainable development is mentioned in the standards, but it is not compulsory and the decision to integrate it into the curriculum lies on the teaching staff and university management. That is why most of the expert are stating that the decision to integrate sustainability is highly influenced by the personal initiative of the teachers and of the heads of departments.

One of the experts was describing the situation as follows:

"This is an objective necessity, teachers are quite educated and thinking people and they also begin to see that one thing is not enough, that there is some kind of set of requirements, a set of approaches that must be implemented in order to be successful and then they start to get interested, well, of course, there is a concept of sustainable development of rural areas, which is declared and which is being implemented, but there is a mutually directional movement, both from the teachers and from those who establish educational standards."

A constellation of these forces is providing successful integration and until there is no clear program from the state the integration of sustainability topics will stay scattered and highly dependent on the initiative and interests of the teachers. Beside the ministries of education and agricultureб an important role could play public organizations for example agricultural education association which provides a methodological support of educational programs, coordinates the work of the university, according to the experts they have the resources and influence.

5.1.5 Competencies provided by education for sustainability

Following competencies were discussed during the interviews: innovative structures; foresighted thinking; planning and implementation; interdisciplinarity; participation; cosmopolitan perception; empathy; self-motivation and motivation of others.

Experts were asked for assessment how these competencies are covered in frames of the education. All the experts admit that most of the competencies are presented in the state federal educational standard and there are courses which are providing the competencies. For example, there are such

courses as strategic management and planning and innovation management. Interdisciplinarity is also an important feature of the education and universities are making attempts to provide students with expertise in different fields.
There are also courses that are training communicational skills and teamwork.
Many experts admit that there are some problems with teaching impact assessment techniques, and the experts stress that there is a need to strengthen this competence.
All the experts admitted that they are stressing the importance of the global perception of the situation, but there is a certain confrontation with the state politics.
Empathy is also questionable in the current political situation and the implementation of this competence strongly depends on the teacher's personal vision.
There were an interesting range of reactions to the competence of self-motivation and motivation of others to change the way of living. Some experts admit that motivation and students' readiness to accept information about the importance of lifestyle changes strongly depends on their age. This competence is not stated in the federal educational standard and some of the expert's don´t think that it is their responsibility or that it is possible.
Nevertheless, there are examples of the teacher who are trying to highlight the importance of this competence. For example, an expert from Stavropol state agrarian university in frames of the university course "Environmental economics" has offered students an opportunity to create their own small projects with aims of rising sustainability awareness. These projects received support from the university management as well as from students, who saw different opportunities of more sustainable lifestyle.
Discussion of competencies with experts usually boiled down to the fact that almost all competencies are presented in education in one form or another, but there is a need to systematize these competencies and link them to a main goal of achieving sustainable development in frames of professional activity.

5.1.6. Post-graduate education and life-long learning

Opinion on the opportunities for education in the sphere of sustainability for university teacher were very different. 10 out of 16 experts were stating that there are enough possibilities for teachers. The training offered by the university usually includes various courses that are mostly devoted to the organization of the learning process, inclusion, distance learning. Participation in conferences or forums are leaded by the personal initiative of the teachers. And many experts have admitted that there is enough information about sustainable development, but a huge part of the information is available only in English and not all university teachers speak English, which limits access to the information.
The fact that 10 out of 16 experts were stating that there are enough opportunities is maybe connected to the fact that most of the experts are active and initiative and have experience in different projects.
Some of the experts admitted that the possibilities for teacher are limited by universities financing and it strongly depends on the status of university, in Moscow possibilities are wider due to better financing and due to the high level of networking between Moscow and foreign universities. In regional universities the opportunities are limited.
Also, experts admitted that financing of training changed in last years, early it was financed from government funding and now it goes by university expense. That is why teachers are keen to participate in different projects and grants, because it is a very good opportunity to improve their competences. Also, one of the experts admitted that especially in a disadvantageous position are many young teachers who have heavy workloads and they do not have time to apply for a grant, and they do not have time to do their own scientific research.
Heavy workload was admitted by most experts (11 out of 16 experts), especially they note that there are a lot of organisational things and meetings which are very time consuming, and which are directly reduce the quality of education.

One of the experts admitted that there is a need in improving the competence of teachers, not only in the content, but in a willingness to go beyond the scope of their specialty and more comprehensively and more globally. Now the teacher could rise their competence only in the frames of European projects or by doing research in the topics by own initiative. And one of the experts, who was assessing the training opportunities for teachers rather critically had suggested that there is a need for systematic concept of life-long learning for sustainable development and it could be seen that the system is missing on all level of the education starting with school education and ending with training of professionals and teaching staff.
During the interviews the question if teachers are ready to integrate the sustainability topics into education was discussed. There were different opinions on this topic, the experts from 4 universities with integrated master program were united that they received a good training in the project SARUD, and they are ready to integrate sustainability into teaching process. Nevertheless, the experts who were involved in SARUD evaluation admitted that there is a gap in teaching staff, and it was difficult to find teachers who could teach the disciplines with sustainability topics. During the project the teachers were trained, but the question remains what happens when the teachers decide to change their job whether the topics will remain in the study plan and who will teach them.

5.1.7 Recommendations for possible measures

During the interviews the issues hindering the integration were discussed, problems and possible measures are presented in the table 5.2.

Table 5.2 Problems and possible measures

Problems	Possible measures
Incoordination and competition between departments and ministries	Interdepartmental centres Interdisciplinary working groups
Overload of teachers	Optimization of the workload on teachers, redistribution of organizational responsibilities
Lack of practical examples	Organization of field trips and search for best practice
Absence of system in the education	Creation of a systematic concept of education for sustainability Need for standards Clear statement in federal educational standards
Limited financing	Re-orientation of management priorities
Lack of system flexibility and frequently changing standards	Avoiding strict frameworks and standards to maximise flexibility
Lack of connection with business	Involvement of business in research and educational projects
Lack of state support	Creation of a systematic concept of education for sustainability

Source: own elaboration

Many experts are highlighting the incoordination of different ministries and institutions within university and a clear need for interdepartmental centres in some form which could unite the work in terms of sustainability, and it is needed on governmental level as well as on university level.
Interdisciplinary working groups were also mentioned by some experts, as a solution for the problem, such working groups could be a suitable substitute for a centre without high investments and with high level of flexibility. But the problem is not only in the incoordination between the

departments, but also in the competition. The integration of new disciplines on sustainable development can occur by changing existing disciplines and adapting them to new conditions. For example, in almost all majors there is such a discipline as philosophy, theoretically it is possible to integrate topics on sustainable development into this discipline, but this is possible only with the consent of the teachers and their willingness to study this topic, if the teachers are not interested or they do not have enough training, then these topics could be taught by other departments, then the philosophy department loses its teaching hours and, accordingly, earnings.

During the SARUD project, a huge amount of work was done in universities to convince teachers in the importance of disciplines in the field of sustainable development and the need to share teaching hours. Without such an incentive as a European project this task becomes almost impossible and it is only driven by a personal initiative of teachers, who are interested in sustainable development.

During the interviews one of the controversial issues was the influence of the government. From one side one of the experts have admitted that constitutional reform in summer 2020 creates conditions for the development of the systematic environmental education of citizens and could rise environmental awareness. But from the other side experts have fears that these intentions will remain only on paper and in the absence of a formed concept there will be no desired effect.

The theme of lack of system in sustainability education was often mentioned during the interviews. This topic was often linked to the fact that sustainability is mentioned in the federal state educational standards, but there are no directives how the sustainability should be presented in the curriculum, and there are no rules if sustainability topics should be included as disciplines or topics, if it should be in all majors or not.

Many of the experts are stating that sustainability concept should be a compulsory part of curriculum and it should be mentioned more clearly in the federal state educational standards.

From the other side there were some sceptical opinions among experts. Firstly, educational standards are advisory in nature, and they define a set of competencies that students should receive. Some of the experts noted that the transition to competency-based standards was quite difficult. In many universities, the average age of teachers is quite high, and it was difficult for them to adapt to new standards, and often they tried to tie up the existing disciplines to new standards, therefore the introduction of new standards and requirements does not guarantee the correct integration of a particular topic into education.

Secondly, many experts noted the high levels of workload on the teaching staff, they especially noted the fact that teachers are overloaded with organizational work and in the context of constantly changing standards and the need to adjust to them, there is a great risk that the quality of teaching will suffer due to lack of resources and time of the university teachers.

Thirdly, despite of the recommendation character of the federal state educational standard there are still some strict frames that are limiting the integration. For example, there is a classification of all the majors and every major should pass to one of the classes and it makes the integration of the multidisciplinary majors almost impossible. Therefore, experts were united in the opinion that sustainability should be present in the standards but making it compulsory will not bring the desired effect.

Experts admitted that there is a lack of practical examples and best practices, which could highlight the importance of sustainability to both students and teachers. There is a clear need for experience exchange, study trips and trainings. The exchange could also happen between Russian universities, it should not always be with European partners, now the exchange between Russian universities is limited since it is not considered as important by university management, and it is not supported financially.

An important issue, which was admitted by many experts is the absence of systematic approach towards development of study plans. There are some definite gaps in the education for sustainability in Russia, and it should be developed not only on graduate level, but also on school

and post-graduate level. There is a need to educate people who are already working with implementation of sustainability programs.
The problem of school education was also discussed with the experts, and it was interesting to find out that even among experts there were opinions that sustainability topics are not suitable for school education, and some of them even think that it makes not a lot of sense to integrate sustainability topics on the bachelor level. There is a definite understanding gap and there is a need to train teachers in didactic methods of integration of sustainability topics at different levels of education, and it is necessary to pay special attention to the teacher´s training so that they understand the need to take sustainability into account in all areas of education and that it is one of the education's aims to rise sustainability awareness.
This problem could be solved with a lifelong learning concept of education for sustainability, this concept should include consequent integration of sustainability topics starting with school education and continuing in bachelor and master´s and it should be also present in training programs for professionals and teachers.

5.2 Conclusions

During the expert's interview in Tambov region, it became clear that most of the agents, who are implementing such federal programmes in sustainable rural development, do not have a clear understanding of the concept of sustainability. Usually the question "what do you understand by the term sustainability" was answered according to the sphere where a person was working. For example, an officer of agricultural ministry was explaining that sustainable development is limited to a provision of enough infrastructure for rural areas.
This is also reflected in the scientific literature – one of the statements from the literature research was that there is presence of the sustainability concept in the official documents, but many researchers admit the lack of implementation and understanding in practice (Azizova, 2015; Ilin et al., 2017; Pavlova, 2013).
Most of the interviews confirmed this fact, the term sustainability is often mentioned in state documents. For example, it is mentioned in the federal state educational standard, but this mention does not set any framework for integration of sustainability concept into education. It does not set any rules, and even when the sustainability topics are beginning to infiltrate academic disciplines (mostly driven by personal initiative of the teaching staff) it is still education „about sustainability", but not "for" sustainability.
Most of the experts were highlighting that it is crucially important to set a clear framework of the integration of sustainability topics in the federal state educational standard. Only than a wide integration of sustainability could be possible.
Some experts noted that it is important to highlight to teachers that sustainability in the context of education is not only about different aspect (economic, social, environmental), but paramount importance have competencies for achieving sustainable development, which students can apply in their future professional activities.
One of the conclusions from the interviews was the fact that integration of the sustainability topics is very different in different university and within a university integration is also very different. The range of integration lays between slightly mentioned in basic disciplines to specialized master programs.
One of the statements form the literature research was the fact that there is a lack of educational programs with sustainability majors. After the interviews it is difficult to say if there are enough programs with sustainability majors, but according to the experts there is a need for professional education which will encompass sustainability topics and it should be present preferably in all study majors.
On the base of the interview a conclusion could be drawn that university education is not only about giving the students competencies and methodologies, but it is of crucial importance to teach

students to think, to assess situations critically and evaluate their professional decision and projects in terms of sustainability.

The experts for the interviews were mostly from the agricultural universities and the statement that sustainability education has transformed form the ecological education, and it is often confused with ecological education was not confirmed during this research. As in agricultural universities the topic of sustainability is mostly connected with the development of rural territories and the topic of sustainability was an answer to the request for complex and harmonic development.

There are problems with interpretation of the term sustainability, and neglection of the concept´s complexity. From one side the understanding that there are different aspects that should be considered, and it is a huge step forward as just a few years ago the most important thing in development was the increasing economic capacities and all other factors were neglected. Nevertheless, the understanding that education for sustainability is not a set of disciplines or topics, it's another quality of the educational content aiming to the creation of new way of thinking, new worldview, moral norms of safe life in the context of global processes is missing.

The experts during interview showed understanding of the fact that the topics and disciplines concerning sustainable development are there, but a certain link is still missing, a link that will ensure transdisciplinary educational content and will be leading to the new integrative activities.

Crucial point of the education for sustainability is the educating critical and systematic thinking of the students and to reach this goal an assistance of all parties is needed. First, there is a need for assistance from the governmental bodies in case of agricultural university they are ministries of agriculture and education. The management bodies of universities and universities' teachers are also playing an important role in this process. It is a complex process with many parties involved, and now in Russia this process is chaotic, and it is mostly driven by personal initiatives.

In the chapter 5.1.7 the problems which are blocking the integration of the sustainability into education and possible measures were listed, but the success of these measures depends on the general approach and if the importance of sustainability will be present only in official documents, then there will be no shift in integration, and everything will depend only on individual initiative teachers.

Discussion

6.1 Sustainable development

World population is growing (United Nations, 2019), and the needs of the population could be only satisfied with the respective growth of production and industries. At the same time the awareness that the growth should be assessed not only in economic terms is making the topic of achieving sustainability more important every year, sustainability is discussed on different levels on political, entrepreneurial and on citizen´s level (Lyytimäki et al., 2014b; Shepherd et al., 2005; Vermeir and Verbeke, 2006). In 2015 the SDGs were adopted by 193 country with an aim to resolve the social, economic and environmental problems troubling the world (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019).

Russia has adopted sustainability development goals in 2015, but in 2019 there were no public statements from the governmental officials about the implementation of the global goals and no regional measures to achieve them, also no comprehensive stakeholder engagement mechanism has been developed (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019). On the contrary, Russian Federation and USA are two countries which are reported to be doing the least to achieve the SDGs (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019).

According to the Sustainability development report in 2019 the most successful aims were SDG 1 "Poverty eradication", SDG 4 "Quality education", SDG 8 "Decent work and Economic Growth", for all other goals significant challenges remain (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019). But even if some of the goals are assessed as reached, it does not always reflect the realistic situation, for example SDG1 "Poverty eradication" is assessed with 2 indicators Poverty headcount ratio at $1.90/day and $3.20/day (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019), which is very low for Russian condition and with such indicators it is not possible to draw a conclusion that the goal is reached (Radchenko and Rakhimova, 2020).

There is moderate improvement trend for 8 goals including zero hunger; good health and well-being; gender equality; clean water and sanitation; affordable and clean energy; sustainable cities and communities; peace, justice, and strong institutions; industry, innovation and infrastructure (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019).

There is a stagnating trend for 3 goals – climate action, life below water and life on land. For the goals, partnership for the goal, responsible consumption and production, and reduced inequalities the data is not available in dynamics (Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019). There were some critical voices about the missing data, as for example for the goal reduced inequalities official statistical data is not collected, as the collection of the statistics for the inequality issues in aspects of the problems of migrants, indigenous peoples, LGBT people, contradicts to state policy and interest (Radchenko and Rakhimova, 2020).

The official position of the Russian government is that from one side there are a lot of challenges, but from the other side with an adequate support and correct action on political level the SDGs could be reached (Analytical center of government of Russian Federation, 2020; Bertelsmann Stiftung and Sustainable Development Solutions Network, 2019). The critics of the state reports on SDGs are highlighting that even with the correct legislation and political measures the goals could remain unreached in case of incorrect implementation (Radchenko, 2020; Radchenko and Rakhimova, 2020).

One of the factors which is causing problems of the implementation of the SDGs is a missing governmental structure which is responsible for sustainability. Lanshina et al. (2019) underline the importance of creation of an interdepartmental working group under the presidential administration to combine issues related to climate change and provision of sustainable development. Such a working group should regularly discuss aspects of the implementation of SDGs with regional and

municipal authorities as well as collaborate with international organisations to use the experience of other countries (Lanshina et al., 2019).

For Russian regions tailored solutions are needed to reach the sustainability goals. In 2016 an Interdepartmental Working group on climate change issues and sustainable development was created under responsibility of administration of the President of Russian Federation (Surinov, 2017). But responsibilities of this group lie in organisation of statistical data collection for the assessment of sustainability and there is a need for such a group with broader range of responsibilities covering: monitoring of the progress, analysis of collected data, discussion with local authorities of possible measures to reach the aims of sustainability and presentation of the results to the public.

This research has shown that with the application of the composite indicators it is possible to assess the development direction of the region and it is important that such indicators are adapted to the needs of the certain regions, because the regions differ strongly from each other.

Coordination and management are of crucial importance in implementation of SDGs, the complex and intersectoral character of the aims needs a sophisticated implementation mechanism. In Russian condition not only horizontal hierarchy is important, but the vertical connections are playing an important role – coordination of national, regional and local levels (Bobylev and Grigoréva, 2016).

The principles of sustainable development are implemented only in few regions of Russian federation (Bychkov et al., 2016) and there are several reasons why the sustainability policies are failing, Howes et al. (2017) have classified these reasons in three groups: interrelated structural causes, implementation traps and knowledge/scope issues.

Interrelated structural causes are underlying cause of policy failure (Howes et al., 2017), it could be economic – as disconnection between economic markets and environmental sustainability, resulting in market failure. The market failure can be caused by inefficient allocation of resources, over- or under-production, and by poorly designed regulations which are discouraging investment in innovative environmentally sustainable solutions (Hildén, 2014; Howes et al., 2017). This is also applicable to Russia as the environmental factor is often neglected in development strategies of Russian regions (Bychkov et al., 2016), and maintenance of relatively high level of economic development occurs at the expense of environment. The Russian government is trying to transform from resource-intensive economy since 1990th, but this process is not so successful, because there are no direct incentives for this transformation (Makarov et al., 2020).

Howes et al. (2017) has also identified incentive failure as one of the implementation traps, apart from wrong incentives there are several implementations traps categories (Althaus et al., 2013; Howes et al., 2017; Kraft and Kamieniecki, 2012), which are applicable to Russia, first of all the incomplete specification of aims or objectives.

The decision to implement it or not and how is usually taken on a regional level. There are some directives from Russian government, but there are usually limited to such narrow measures as “collecting certain statistical data” or “implement a federal program of supporting rural schools”. These directives are usually missing a broader view on all the aspect of sustainability, and this problem is also very important in context of monitoring (de Olde et al., 2017; Reyers et al., 2017; van der Linden et al., 2020).

Another two implementation traps which are also important are conflicting objectives within or between policies and conflicting directives from agencies or senior officials, there is an example of such problem even during monitoring of sustainability, as one of the SDG indicators is accessing the corruption level and some of the governmental critics are stating that governmental structures are not keen to collect such statistics as it could reveal their ineffective work (Radchenko and Rakhimova, 2020)

One of the implementation traps stated by Howes et al. (2017) is inappropriate agency for implementation, which is relevant for sustainability, as the measures are often intersectoral and they are influencing different aspects of sustainability. For example, in Tambov region the ministry

of agriculture is implementing almost all rural development programs, and even if they name the program "for sustainable rural development", they are mostly concentrating on the social and economic aspect neglecting the ecologic component.

There are some attempts to manage the human influence on the environment. For example, an energy strategic plan was adopted in Russia in order to limit the burden of energy industry on environment, the measures of this plan included (Gostev and Gosteva, 2013):

- creation of economic incentives for the use of environmentally friendly energy-efficient and resource-saving technologies in production
- development of a system of legal regulations, standards, and norms to tighten control over compliance with environmental requirements
- support of strategic environmental audit initiatives.

There are some positive examples of environmental regulation measures from another countries, which could be also adopted in Russia. For example, emission reduction credit or capped allowance systems are successfully used in US, the U.S. acid rain program is cost-effectively reducing sulphur dioxide emissions form electric utilities (US EPA, 2021).

In EU the emission trading system is considered the flagship EU climate policy, where a binding, annually reducing carbon emission cap, has been put into place to provide a strong price signal for cost-effective greenhouse gas abatement in the European electric power sector (Bruninx et al., 2020).

The plans of Russian government are confirming that there are already specific steps taken to create the basis for legislation for the environmental policies (Gostev and Gosteva, 2013). Nevertheless, the transition of a country to a sustainable development is a complex procedure and, critically speaking, the forecasts of climate change and growing ecological problems are posing new challenges for Russia and the rest of the world. To overcome these challenges there should be adequate response in a form of strategic measures from the governmental bodies.

Sakharov and Kolmar (2019) have performed a content analysis of the strategic documents for sustainable development, an aim of the research was to find out how the SDGs are covered in these documents. In general, in the priority development areas most SDGs were reflected, but the authors are admitting the lack of consistency in the implementation of the SDGs (Sakharov and Kolmar, 2019b).

The only aspect of SDGs that was left out in Russian conceptual documents is social justice and the promotion of human rights. Sakharov and Kolmar (2019) are explaining this by the fact that the Russian politicians do not consider these problems as a priority in terms of ensuring economic growth.

Analysis of the goals and activities for the implementation of the SDGs reflected in national conceptual and strategic documents, showed that there are substantial resources to increase the effectiveness of achieving the SDGs through the implementation of a comprehensive new approach that ensures the unity and balance of social, economic environmental and environmental aspects of sustainable development. Most suitable option would be to adopt a comprehensive sustainable development strategy, including both national priorities and sectoral tasks (Sakharov and Kolmar, 2019b). The success of such strategies is directly connected to the effectiveness of administrative structures which are managing the process of implementation, and the administrative structure needs effective tools for sustainability monitoring.

Reaching SDG is a challenge for all the countries, and it requires efforts from wide range of stakeholders. On one hand there is a lot happening around the topic of sustainability in Russia, there are different strategic documents, there are concepts and working groups, but on the other hand there are a lot of critical voices saying that this work is not bringing real implementation and all the strategies stay just "on-paper" and the question "What should be done to change this situation?" stays open.

6.2 Sustainability assessment

One of the subjects of this research was the assessment possibilities of sustainable development. A mix of composite indicators and regional assessment were offered as possible tools for assessment. The composite indicators are multidimensional measures and the use of indicators for sustainability assessment is a complex process and as there a lot of subjective decisions which should be taken, the assessment process offers a vast field for manipulation. To measure sustainability, one needs a list of indicators and possibly a composite index and opportunities for manipulation are becoming even wider. Sometimes the use of indicators is clearly manipulative, aimed at securing political or financial interests (Lyytimäki et al., 2014a).

Now, the sustainability assessment in Russian is only possible as a fragmentary analysis of the available statistics, which reflects different aspects of sustainable development. Because up to now there were no statutorily defined indicator of sustainable development (Bedrickij, 2012; Galkina, 2013). The use of composite indicators for sustainability assessment is innovative for Russia, composite indicators use was not widely reported (Ferova et al., 2019; Kalmykova, 2013).

There is a need for a monitoring system for sustainable development, the monitoring should be a continuous assessment process with a set of indicators, covering all aspects of sustainability, followed by dynamics analysis, identification of dominant trends, future forecast and timely measures to eliminate adverse changes violating sustainable development (Analytical center of government of Russian Federation, 2016; Bobylev and Pereleta, 2013). The result of the monitoring should be available to federal and regional authorities, now there is no such mechanism of monitoring on a federal level in Russian Federation (Bedrickij, 2012; Galkina, 2013).

Monitoring and evaluation should be seen not as an exercise in reporting, but as an active management tool that helps adjust the strategy along the way. Another challenge is that monitoring and evaluation frameworks tend to target specific policy interventions (e.g., a single policy or the program in a particular sector), whereas it is important to assess overall progress towards interrelated goals and targets (United Nations, 2018).

There are several challenges in a way of monitoring of sustainability:

- missing statistical data for the assessment
- quality of available statistical data
- problems in the coordination of responsibilities betwenn different departments
- lack of the scientific research in the area of the sustainability indicators tailored to Russian regions.

In 2016 Federal service of statistics of Russian Federation has analysed available data for the assessment of SDGs (Surinov, 2017). Statistical data is available for 65 % of indicators, the rest of the indicators the statistics are either not available or needed data is „ownerless", meaning the indicators are not under resposibility of a federal or executive authorities (Surinov, 2017). Surinov (2017) is mentioning such "ownerless" indicator as the main challenge for the data collection, another problem is the fact that the data is often available only on highly aggregated level and no comparison is possible across regions.

Bobylev and Grigoréva (2016) in the report of human development of Russian Federation are admitting, that there is a time lag between collection of the statistical data and analysis. Data collection during three and more years is not providing an opportunity to manage the development in real time. In order to reach the ambitious SDGs there is a need of investment in national statistical systems (Bobylev and Grigoréva, 2016).

As recommendation, a composite indicator should be adopted for regular assessment of the achievement progress and for evaluation of strengths and challenges. A composite indicator could be created on the base of already available statistical data, but in the future, it should be modified and collected indicators covering the SDGs should be added.

Bedrickij (2012) is admitting that many of the indicators which are ususally used to assess the sustainability on national level are not collected, but replaced with estimates of international

organizations. Such estimates are increasing the level of uncertainty of the assessment and it is higly important to collect representative statistical data to create a reliable composite indicator.
There are some works by scientists (Rodionova and Lipina, 2015; Tereshina and Degtyareva, 2012; Zakharova, 2011) attempting to create indicators for sustainability assessment, but the approaches are completely abstract and the resuls are uncertain. There are list of indicators which could be used, but it contains no methodological approach to the problems (Vukovic et al., 2019).
There is a clear need for further development of the indicator assessment on a regional level in Russia. One of the possibilities for development is to use the framework used by OECD for assessment the progress towards SDG (OCDE, 2019). The framework uses the UN Indicator List and is assessing whether the indicators have been moving towards the target levels. The target levels have been set with reference to the level of ambition embodied in the Agenda 2030, if it is not set in the Agenda, then the OECD framework relies on international agreements and expert opinion, and in the remaining cases on benchmarking against the top performing 10% OECD countries (OCDE, 2019).

Table 6.1 SWOT analysis of the composite indicators use.

Strengths	***Weaknesses***
Presentation of complex multidimensional issue in one aggregate value. Continuous monitoring is helping to improve performance and achieve targets. Indicators are giving clear signals of unsustainable trends. Composite indicators could be created on the base of data which is already collected for other purposes. Sets sustainability as definite target to be reached. Facilitate engagement with the public and promote accountability.	Too many subjective decisions during the composite indicator creation. Complex models are easy to misuse and misinterpret. The sustainability is assessed only by what is possible (and easy) to measure. Neglection of the unknown consequences. High workload of the composite indicator creation process. Difficulty to keep balance between two simplistic composite indicators and incomparable between different regions.
Opportunities	***Threats***
Implementation of the assessment techniques will stimulate the need for education and sustainability awareness. Increase of the comparability of the development over time and over different regions.	Incorrect interpretation due to lack of knowledge. Neglection of important aspects for which data is not available or which is difficult to measure.

Source: own elaboration
One of the possible direction of futture research is to test the applicability of the OECD framework to the Russian regions and firstly theoretical framework should be developed thus different assessment criteria specific for different regions should be elaborated and a methodology to unify those criteria to make comparison across regions possible. Also there is a need for development of impact asessment models for evaluation of the strategies influence on sustainable development on different levels.
Another important issue, which needs further research, is measuring the pace of change, OECD framework is not answering the question if the desired effect will be reached until a certain point in time. Also the targets for SDG should be explicitly set for Russian condition, if the OECD

framework is taken as a basis for assessment, the questions is whether the tragets used for OECD countries will be applicable for Russia, this topic also need investigation.
In course of the research for this dissertation different methodologies for composite indicators were analysed and a question has aroused, if it makes sense to use complex models to assess sustainability for a regular monitoring. Not all the tools, which are produced by science, are adopted by policymakers. There has been a strengthening of political commitment to improve the evidence base of policy making, but it did not lead to the institutionalization of assessment tool use especially the more advanced types (Nilsson et al., 2008). And the study performed by Nillson et al. (2008) have shown that the selection of tools is likely to be primarily based on organisational routines and standard practices and on the expectation that they will produce evidence that supports the core beliefs of governing coalitions.
From one side the use of indicators is reasoned by the fact that indicators are representation of knowledge, selected through best available procedure and easily interpreted (Chess et al., 2005). But from the other side it is quite often that scientist´s construction of indicators could be misinterpreted because it lacks non-scientists perspective (Webler et al., 1995). To make sure the composite indicators of sustainability are correctly interpreted, it is important not only to develop scientific frameworks, but to organise trainings for the policymakers, who will use the indicators in their work.
Apart of the indicator creation process, there is also communication process when the results of assessment are presented to decision-makers and public. And indicators itself could be understood in various ways, depending on the communication context and knowledge values, interest and abilities of indicators user (Alabaster and Hawthorne, 1999; Chess et al., 2005; Lyytimäki et al., 2014a).
Alabaster and Hawthorne (1999) more than 20 years ago admitted that public is often overloaded with environmental information, and it is not always possible for the citizens to find and utilize the correct information about sustainability. Since then, a lot of things have changed and now it is easier for normal citizen to get the information, but it has also become easier to get lost in the information available.
From a quick glance a composite indicators and rankings could be a useful instrument to deliver the sustainability information to the public, but Lyytimäki, Gudmundsson and Sorensen (2014) argue that a composite indicators use have many shortcomings and unitended effects, that indicators are only pointing the direction of development, leaving the user with considerable freedom to interpret the desirability of development.
For example composite indicator could cause obfuscation – confusion and misunderstanding created by the message, due to the highly aggregated nature. The risk of obfuscasion increases when composite indicator is used as a tool to reach large and diverse target groups of non-experts with highly varying knowledge, values and interests (Lyytimäki et al., 2014b). Composite indicator for sustainability assessment defenitely runs such risk, because it is highly aggregated and is covering a broad spectrum of topics, in order to limit the confusion a presentaion of composite indicators should be accompanied by an access to more detailed data.
Another uninteded effect which could occur during the communication of composite indicator to the public is “dissonance”, this effect could lead to lack of belief in the results of rankings, when the message of composite indicator is differing greatly from prevailing beliefs and expextaions. Lyytimäki, Gudmundsson and Sorensen (2014) sugesst to use indicators to evoke interaction, debate and consideration of the reasons for dissonance.
A person who is developing a composite indicator should have a clear aim in mind and when results of the research are communicated to the public or to policymakers, a researcher should keep in mind a possibility of unintended effects and that there is a possibility to use these effects to reach the set aim.
To draw a line, there is a need for organised monitoring of sustainability in Russia; but such an assessment will be effective only under conditions of transparency of the reporting. The problem

of establishing an effective assessment of sustainability is multicomponent, firstly, it is important to develop theoretical foundations for creating a set of indicators which will reflect the development direction towards or away from sustainability, secondly, it is necessary to ensure the collection of reliable data on these indicators, and thirdly, it is essential to train employees working with these data for the competent creation and interpretation of composite indicators. Another important issue is the training of the professionals in terms of sustainability, because to assess sustainability is only the first step, the next step is the right interpretation of the assessment and correct policy reaction, which is not possible without a solid theoretical background in sustainability.

6.3 Sustainability education and awareness

In the chapter 6.1 some of the implementation traps of sustainability measures identified by Howes et al. (2017), there are few more traps which are linked to the educational and awareness problems in Russia: limited competence of agency or those tasked with implementation and a failure to communicate with the affected community. It is also confirmed by Bychkov, Ageev & Dolgikh (2016) that the main obstacles to the implementation of the principles of sustainable development are:

- difficulties in perception of the topic of sustainable development
- a lack of expertise and experience and low qualifications of staff in municipalities
- a short-term planning horizon.

Research in the Tambov region, as well as the interviews with the experts from Russian universities revealed issues in the education for sustainable development. One of the problems in Russia is the fact that sustainability is represented only "pointwise", word sustainability is often used in the names of development programs, but it is understood as "stable" development of certain economic or social aspects, ESD is missing consistency and systematic approach (Zhevlakova, 2013).

This concerns the federal state educational standard as well as educational activities itself. This leads to the problem that the education is not for sustainability, but just about sustainability (Dzyatkovskaya and Zahlebnyj, 2016; Zhevlakova, 2013). Such education is informing students about existing global problems, but it does not offer them tools to mitigate them, and it does not motivate them to direct their professional activities in accordance with sustainability principles, and it is unlikely that this "pointwise" character could be changed by methodological recommendations for teachers. Dzyatkovskaya and Zahlebnyj (2016) are stating that it is necessary to revise the ideological orientation of the content of all subject areas, to introduce end-to-end value-semantic lines and adequate tools for actions into them.

In order to transform the education "about" sustainabiltiy into education "for" sustainability there s a need to accumulate critical mass of ecological collective consiousness in the educational environment. In different countries it is achieved though games, trainings, projects dedicated to various aspects of sustainable development (Dzyatkovskaya and Zahlebnyj, 2016). In Russia such methods are not widely used and in order to aplly them there is a need for a concept of general education for sustainable development.

One of the topics that arose during the interview was the inertia of civil society in Russia. Many experts noted that there is little interest in sustainability among the population. Some experts attribute this to the fact that the opportunity to worry about sustainability issues appears after a certain level of well-being. In an environment where people or organizations are struggling to survive, there can be no question of them worrying about future generations.

One of the most influential social scientific efforts to understand public opinion has been political scientist Ronal Inglehart´s analysis of the World Value Survey, this has led to the development of his "postmaterialist value thesis", which contrasts individuals preoccupied with material, economic concerns and those who are said to have transcended this preoccupation to be motivated by "postmaterialist" values focused on quality of life, self-expression, and self-fulfilment (Inglehart, 1990). If this theory is applied to the environmental or to sustainability concerns, then it presumes that these are subjective values that tend to be activated only once more fundamental and material

needs are met. But many scientists admit that there is more than one sort of motivation for such concerns and in many cases it has rooted in a concern for livelihood and material vulnerability or the survival of a way of a life (Dunlap and York, 2008; Inglehart, 2017; Kalfagianni et al., 2019; Kim and Wolinsky-Nahmias, 2014). John Meyer (2019) in his work is stressing the fact that it is important to draw attention to the diversity of spaces and opportunities for sustainability strategies that resonate with the everyday concerns of many (Meyer, 2019).

On the other hand, experts noted that the first glimpses of interest in issues of careful attitude to resources appear, and various volunteer movements are emerging. One of the experts believed that for the issues of sustainability to be more actively integrated into the educational process and into everyday life, a mutually directed movement is necessary both from below and from above. Therefore, on the one hand, there should be support and interest on the part of the authorities, on the other hand, civil society should be aware, interested and actively participate in various events.

Dobrovidova & Davydova (2013) have researched the appearance of the ecological themes in Russian media sources, and they have admitted that ecological issues are covered inconsistently. Critical importance in the formation of the ecological culture and sustainability awareness has regional mass media. At the moment the main way of disclosing of environmental issues in the media is through conflicts (Dobrovidova and Davydova, 2013). Moreover media often become active participants in local environmental conflicts, recent example is a conflict around Kushtau mountain in Bashkiria, where local media put enough pressure to get a nature protection status for a mountain (Gorbacheva, 2020).

Given this mutually directed movement, the education system could act as a mediator between the population and the authorities. Most likely, it is impossible to ensure the integration of sustainability into the lifestyle if the source of integration comes only from one of the participants. The state should support civic initiatives, actively encourage the introduction of sustainability topics in education, and encourage organizations to implement sustainable development reporting; civil society should actively participate in government programs.

In the interviews, the question of the need to reform the education system was raised, including the need to abandon the rigid framework in the form of categorization of specialties, which greatly complicates the introduction of new areas of training, since they do not fit into the catalogue. This transformation will give an opportunity to launch more interdisciplinary majors, which the Russian educational system is lacking now (Yurina et al., 2019).

In the UNESCO report on issues and trends in education for sustainable development it is underlined that efforts in ESD should be monitored and assessed (United Nations, 2015c). This monitoring should help ensure on-going relevance and effectiveness of ESD efforts, guide planning and reorienting of educational programmes, increase understanding of ESD progress, and if participatory evaluative frameworks are used, the process can also build knowledge among stakeholders (Tilbury, 2007). One of the possibilities for such assessment are indicators according to Tilbury (2007). Monitoring and assessment of ESD could become a sphere, development of which in Russia could be used as a platform for involving actors from all social sectors in learning and change for sustainability.

The situation with education in the field of sustainable development in Russia is ambiguous, on one hand, the topic of sustainable development is officially seen in documents, there are educational programs, there are disciplines dedicated to sustainability issues, but on the other hand, the presence of educational programs or disciplines does not guarantee the transfer of knowledge and a rise of sustainability awareness. The development of ESD lacks consistency and a broader approach, therefore there is a need for a strategic concept for life-long learning which will include sustainability.

6.4 Concluding remarks

Russian Federation possesses one fifth of the world forests, significant water and other natural resources, that is why the sustainable development of Russian Federation is of crucial importance not only for Russia itself, but of all the mankind (Bedrickij, 2012).

Russia needs a new concept of sustainable development, this program should include an elimination of past environmental damages, modernization of the economy, waste reduction and recycling, as well as development of environmental education and awareness, formation of ecological culture in the society (Bedrickij, 2012).

This research is confirming the fact that after 20 years of history of integration of sustainability concept into Russian policy, there is exess of official documents, but lack of practical action, of adequate reaction to the results of a sustainability assessement and lack of order in administrative institutions.

The research is showing that composite indicator assessment is a suitable tool which could be used for assessment of sustainabiltiy, but there are limiting factors which could only be overcome in case of systematic and consistent changes in Russia. Those changes should cover not only the governmental structures, but also the educational system, which prepares the next generation of professionald who will have to solve sustainability issues in future.

Russian Federation is a rich country in many senses, it has reserves of natural resources, it has huge people potential with high level of education, it has cultural and scientific heritage. This provides a basis for economic transformation and for sustainable development, ensuring social justice, economic stability, and environmental protection. Nevertheless, the sustainainability assessment and the search for solutions to environmental problems is not a fixed goal, but a process. As was mentioned by Floyd and Zubevich (2010) the sustainability thinking is a never-ending process of negotiating the boundaries around what is both possible and preferable and decision-makers as well as scientist must keep it in mind.

Summary
Over the past few decades economic growth has come at the expenses of the environments and the topic of sustainable development is becoming more important. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
The main aim of this dissertation was to investigate the available methodologies of sustainability assessment and to test which of them could be suitable for Russian conditions. Russia is an interesting subject for research as, it has its own history of sustainability science, but quite often the commitment to sustainable development is only in rhetoric and there are some problems with the interpretation of the concept of sustainable development. For example, in Russian official documents the term sustainability is used as a synonym for stable economic growth.
The focus of the research was a creation of an indicator system for a regional sustainability assessment on the example of Tambov region of the Russian Federation. At the first stage of the research a regional assessment was performed with the help of the United Nations set of sustainable development indicators, SWOT analysis was performed to identify the main strengths and problems in the region. Also, the availability of statistical data and relevancy for the research region of the indicators was checked.
During the next stage of the research a composite indicator was created using different techniques for normalization of indicator and weighting. Then robustness and sensitivity analysis of created indicators was performed, the results were visualised, and composite indicators were decomposed to explain the drivers of the aggregated results.
The result of this work has shown that composite indicators together with regional assessment on the base of sustainability indicators are the tools that could support policymakers in sustainability decision-making. There are some problems with the availability of the statistical data in Russia, and there is no monitoring mechanism at the federal district level and lack of coordination with work of statistical agencies. This research is confirming a necessity of further research, and a need to develop a monitoring and assessment system in Russian Federation.
The second part of the research was devoted to education for sustainable development. UNESCO is stressing that the approach of Education for Sustainable Development empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability, and a just society for present and future generations, and therefore education is playing a crucial role in reaching sustainability (UNESCO, 2017).
The aim of this research was to see how the sustainability topics are integrated into the curriculum of the agricultural universities, to define the sources of integration and research possible problems and formulate the recommendations for strengthening the integration. To research the education for sustainable development in Russia first a literature review was conducted, followed by 16 semi-structured interviews with the representatives of 8 universities.
The research confirmed the fact that sustainability is present as a topic in the official documents, for example educational standard, but this mention remains only rhetorical and does not provide the background for the establishment of a framework for integration of sustainability concept. As a result, the integration into education is mostly driven by the personal initiative of the teaching staff.
There is a clear demand for an integration framework of sustainability topics in the federal state educational standard. The main problems are uncoordination and competition between departments and ministries, overload of teachers, lack of best-practices, absence of system in the education and limited financing. These problems could be mitigated with creation of interdepartmental centres, creation of interdisciplinary working groups, creation of a systematic concept of education for sustainability and involvement of different stakeholders into educational projects, but the success of these measures depends on the general approach and if the importance of sustainability will be present only in official documents, then there will be no shift in integration, and everything will depend only on individual initiative of teachers.

Zusammenfassung
In den letzten Jahrzehnten ging das Wirtschaftswachstum zu Lasten der Umwelt und das Thema der Nachhaltigkeit wird immer wichtiger. Nachhaltige Entwicklung ist eine Entwicklung, die die Bedürfnisse der Gegenwart befriedigt, ohne zu riskieren, dass künftige Generationen ihre Bedürfnisse nicht mehr befriedigen können.
Das Hauptziel dieser Dissertation ist es, die verfügbaren Methoden der Nachhaltigkeitsbewertung zu erforschen und zu prüfen, welche davon für die russischen Verhältnisse geeignet sein könnten. Russland ist ein interessantes Forschungsthema. Es hat zwar eine eigene Geschichte der Nachhaltigkeitswissenschaft jedoch ist das Engagement für nachhaltige Entwicklung nur in der Rhetorik vorhanden und es gibt einige Probleme mit der Interpretation des Konzeptes der nachhaltigen Entwicklung. In offiziellen russischen Dokumenten wird der Begriff Nachhaltigkeit beispielsweise als Synonym für stabiles Wirtschaftswachstum verwendet.
Im Zentrum der Forschung stand die Entwicklung eines Indikatorensystems für eine regionale Nachhaltigkeitsbewertung am Beispiel der Region Tambov der Russischen Föderation. In der ersten Phase der Forschung wurde eine regionale Bewertung mit Hilfe des Indikatorensatzes der Vereinten Nationen für nachhaltige Entwicklung durchgeführt. Darüber hinaus wurde eine SWOT-Analyse durchgeführt, um die Stärken und Probleme der Region zu identifizieren. Außerdem wurde die Verfügbarkeit von statistischen Daten und die Relevanz der Indikatoren für die Untersuchungsregion geprüft.
In der nächsten Phase der Forschung wurde ein zusammengesetzter Indikator erstellt, wobei verschiedene Techniken zur Normalisierung der und zur Gewichtung verwendet wurden. Anschließend wurden Robustheits- und Sensitivitätsanalysen der erstellten Indikatoren durchgeführt, die Ergebnisse visualisiert und zusammengesetzte Indikatoren zerlegt, um die Treiber der aggregierten Ergebnisse zu erklären.
Das Ergebnis dieser Arbeit zeigt, dass zusammengesetzte Indikatoren vereint mit einer regionalen Bewertung auf der Grundlage von Nachhaltigkeitsindikatoren die Instrumente sind, die politische Entscheidungsträger bei der Entscheidungsfindung im Bereich der Nachhaltigkeit unterstützen können. Es gibt einige Probleme mit der Verfügbarkeit der statistischen Daten in Russland, keinen Überwachungsmechanismus auf der Ebene der föderalen Bezirke und einen Mangel an Koordination mit der Arbeit der statistischen Ämter. Im Ergebnis bestätigt es die Notwendigkeit weiterer Forschung und das Erfordernis, ein Überwachungs- und Bewertungssystem in der Russischen Föderation zu entwickeln.
Der zweite Teil der Forschung widmet sich der Bildung für nachhaltige Entwicklung. Die UNESCO betont, dass der Ansatz der Bildung für nachhaltige Entwicklung die Lernenden dazu befähigt, fundierte Entscheidungen zu treffen und verantwortungsbewusst zu handeln, um die Integrität der Umwelt, die wirtschaftliche Tragfähigkeit und eine gerechte Gesellschaft für heutige und künftige Generationen zu gewährleisten. Die Bildung spielt daher eine entscheidende Rolle bei der Verwirklichung der Nachhaltigkeit (UNESCO, 2017).
Die Integration der Nachhaltigkeitsthemen in die Lehrpläne der landwirtschaftlichen Hochschulen, die Definition von Integrationsquellen, die Erforschung möglicher Probleme und die Formulierung von Empfehlungen zur Stärkung der Integration ist Ziel dieser Forschung. Zur Erforschung der Bildung für nachhaltige Entwicklung in Russland wurde zunächst eine Literaturrecherche durchgeführt, gefolgt von 16 halbstrukturierten Interviews mit Vertretern von 8 Universitäten.
Die Analyse bestätigte die Tatsache, dass das Thema Nachhaltigkeit zwar in den offiziellen Dokumenten, z. B. den Bildungsstandards, enthalten ist, die Erwähnung jedoch keinen Rahmen für die Integration des Nachhaltigkeitskonzepts vorgibt und die Integration in die Bildung meist durch die Eigeninitiative der Lehrenden vorangetrieben wird.
Es besteht daher ein klarer Bedarf an einem Integrationsrahmen von Nachhaltigkeitsthemen im Landesbildungsstandard. Die Hauptprobleme sind mangelnde Koordination und Konkurrenz zwischen Abteilungen und Ministerien, Überlastung der Lehrkräfte, Fehlen von Best-Practice-Beispielen, ein mangelhaftes Bildungssystem und begrenzte Finanzierung.

Diese Probleme könnten durch die Schaffung interdisziplinärer Arbeitsgruppen, die Entwicklung eines systematischen Konzepts für die Bildung für Nachhaltigkeit und die Einbeziehung verschiedener Interessengruppen in Bildungsprojekte gemildert werden, aber der Erfolg dieser Maßnahmen hängt vom allgemeinen Ansatz ab, und wenn die Bedeutung der Nachhaltigkeit nur in offiziellen Dokumenten vorhanden ist, wird es keine Verschiebung der Integration geben, und alles wird nur von der individuellen Initiative der Lehrer abhängen.

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