

**ECONOMICS
WORKING
PAPERS**

VOLUME 7

NUMBER 4

ISSN 1804-9516 (Online)

2023

ECONOMICS WORKING PAPERS

Volume 7 Number 4 2023

Publisher: University of South Bohemia in České Budějovice
Faculty of Economics

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Faculty of Economics

Edition: 7, 2023

ISSN: 1804-9516

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Sustainable development in road management in the Czech Republic

Ing. Miroslav Němec

Abstract: Sustainable development is based on the historical human need not only to exploit but also to protect the environment necessary for life. However, in the context of the current approach, sustainability encompasses much more than this; it covers a wide range of areas where efficiency in management, approach and governance is required, and the national economy is no exception. Sustainable management and maintenance can help reduce the environmental impacts of individual activities and also reduce, eliminate or recycle waste from individual activities within the circular economy. Sustainable management and maintenance are important because they allow to increase the performance and efficiency of business activities, both in terms of the environment, society and economic efficiency. If the societal goal is to have a quality infrastructure, it is necessary to deal methodologically with the way it is maintained, i.e. the choice of approach, but also the risks involved. There are undoubtedly many of these, which is why it is necessary to concentrate on 'risk management', to carry out a risk analysis and to focus on the most serious risks. It is not about the concept of risk within the function of the organisation itself, where the actual system is implemented, but about the level of risk above the organisation itself, in which external factors are also considered. The intention is to apply Risk Management to the specific conditions of an organization operating in the area of management and maintenance of lower category communications and to find ways to make the organization's activities more efficient so that they meet the conditions of sustainability and therefore can lead to social responsibility.

The basic hypothesis in this contribution is "Using risk management tools can achieve efficiency and thus contribute to the sustainability of social responsibility in the conditions of an organization dealing with road management."

The aim of the thesis is to find a tool for setting up a support system for the implementation of sustainable development in roads sector and intensification of sustainability management at the level of regional roads authorities in the Czech Republic.

Keywords: Sustainable development, circular economy, road management, risk management, infrastructure maintenance

JEL Classification: O

1. Introduction

Sustainability and sustainable development are based on the historical human need not only to exploit but also to protect the environment necessary for life. However, in the context of the current approach, sustainability encompasses much more than this; it covers a wide range of areas where efficiency in management, approach and governance is required, and the national economy is no exception. However, sustainable development of national economic development is not only relevant to the Czech Republic. The need to implement a sustainable approach has become significant in Europe and worldwide in recent years, and despite the many measures taken, it can still be considered a long run. [1]

It is also indisputable that one of the most important areas of sustainable development is the transport sector. There are many different examples of sustainable transport in many documents. The most commonly used definitions of sustainable transport include environmentally sustainable transport, sustainable transport system and process sustainability of the transport system. [2]

The differences between the cited concepts are generally minor, but much greater difficulties arise in measuring the characteristics of sustainable transport, not excluding the roads sector, not only in the basics, i.e. the analysis of indicators, but especially in a multidimensional system aimed at examining the relationship between the various indicators, factors and characteristics chosen to define sustainable transport. [3]

This is because sustainable development is a type of future development that seeks to reduce or eliminate the negative effects of the current development of human society while preserving the current benefits so that the current opportunities are preserved for future generations. The reverberations of past and still receding approaches to resource use, based primarily on economic growth, have irreversibly affected the way the planet and life on it function today. Resources have been used in the past without regard to their finiteness and the impact of their use on the whole ecological system, and therefore to some extent to the detriment and debt of future generations. [4]

In order to achieve truly sustainable development, this approach needs to be changed and current public policies in all their forms, be they legislative, strategic or economic, need to be replaced by cohesion policies, or future sustainability for all. Sustainable development goals apply to all countries, and each of them can contribute to their achievement to some extent. [5]

Roads sector organisations are also facing sustainability issues as they strive to become more efficient in their economic management. There are several reasons that make it difficult for them to achieve this goal in the first place. [6]

First of all, the very definition of sustainable development is problematic, as it is not sufficiently elaborated not only in its general position but also in the structure of the related scientific fields that should act as strategic goals to be pursued in a planned manner. [7]

Another problem is that economic development objectives are not sufficiently specified in terms of the complexity of the internal structure of the individual problems, i.e. with all the related factors that make them up, and therefore do not allow for proper implementation aimed at achieving them. [5]

This is also related to the fact that the strategic definition of economic objectives is not linked to adequate management tools and methods that would allow them to be more easily implemented over time, specifically in the area of strategic management and the application of its tools. [4]

Despite all efforts to change, the development of the economy is still oriented towards the dynamics of relatively isolated technical advancement, without respecting the links with other areas of social development, which in turn creates space for the disintegration of the management of the national economy, which in turn allows the orientation of economic development towards quantitative values that allow the development of consumerism, and the constant growth of consumerism in turn allows the disintegration of management, and as a result, logically also losses in the field of economy. [5,7]

It can be said that success in implementing sustainable development depends to a large extent on collaboration and the availability of comprehensive and quality information from the institutions and individuals involved. But these are only some of the problematic points in the area of sustainable roads sector management. Everything can be, and very often is, influenced by various interests and political and other considerations. [3]

However, the theory of sustainable development emerged as a tool to overcome the undesirable development of the world economy and to strive for its return to ethical values. There is thus a clear contradiction here. Similar problems and efforts to solve them can be found not only in the roads sector, but also in the development of transport and, by extension, the economy of the country as a whole. [2]

The Government of the Czech Republic is currently presenting a roadmap of what the economy should look like in 2030, i.e. with a view to the next 8 years, in connection with measures taken by EU Member States, but also by representatives of individual countries globally. The National Reform Programme of the Czech Republic 2020, which contains measures aimed at restoring the long-term sustainable economic development of the Czech Republic, was approved at a meeting of the Czech Government in May 2020 and at that time was already responding to measures related to the global COVID-19 pandemic. Although representatives of the Czech Parliament, regions and municipalities, as well as other representatives from the economic and social spheres, participated in its preparation

and the document reflects the annual key analytical documents issued by the EU, the basic shortcomings in the road sector and its sustainability are not sufficiently specified or addressed. [6]

The state of the roads sector has been underfunded for a long time and the impacts of current developments in the use of the road transport network are not sufficiently captured in the document in the context of the sustainability of the whole system. [8]

It is often the case that classic cost-benefit analysis is used for financing. In this area, however, it is a cost-benefit analysis that can capture the wider economic implications of conventional analysis, as it considers both the price and non-price implications of roads sector management and maintenance projects. Economic theory typically focuses on conducting CBA as a partial market analysis in which the effect in the primary market (transport market) is partially considered, assuming that all prices in secondary (adjacent) markets remain constant. In reality, it is the effect of large infrastructure projects, as well as repair and maintenance projects, that will have a comparable impact on the whole economy. [10]

The EU is currently proposing recommendations focusing on the need to ensure debt sustainability while boosting investment, yet it does not offer any mechanisms by which the roads sector, by its very nature, can achieve its financing objectives, nor does it offer recommendations focusing on investment and support for SMEs in the context of the European Commission's two major strategic and pro-growth priorities, which does not help the sustainability of the roads sector in any sense. [11]

As stated by the European Commission, the Smart and Sustainable Mobility Strategy, built on the Green Deal for Europe, focuses on how to achieve efficient, digital and green transport by 2050. This strategy replaces the existing 2011 White Paper on Transport - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Although the main elements of the strategy focus on the sustainable development of all modes of transport, i.e. road, air, rail, maritime and inland waterways, it does not focus in any way on the sustainability of current transport structures but rather emphasises digital technologies and the reduction of harmful emissions in transport. [4]

However, in terms of roads sector sustainability, this document does not offer any solution that would allow building on the current situation and take advantage of the possibility of the progressive implementation of sustainable elements in the future. It is true that both the economy and transport are forward-looking, but sustainability measures in these areas must always be based on the status quo.

Planning needs to be based on what is available, whilst measures need to be put in place in the future to achieve sustainability in these areas, since just as it is essential for transport to be economic, it is also necessary for the economy to use transport to continue to grow, because although transport

is a very costly sector, it makes a significant contribution to public budgets through its performance, offering great scope for the implementation of sustainability measures.

Most documents on sustainability focus mainly on sustainability in building or creating new, including infrastructure, with maximum use of renewable resources and minimum impact on the environment.

In the case of infrastructure, however, the focus should be more on the sustainable maintenance of existing infrastructure and how to maintain existing assets more sustainably.

If changes are to be adopted in this area, it will not be without an increase in funding in these areas, which in effect goes against the economic pillar of sustainability.

If the road administration and maintenance are to focus on changing practices towards greater use of environmentally friendly practices in all operations related to the maintenance of the assets and buildings entrusted to it, this will logically entail an increase in financial requirements.

Sustainable maintenance is more than just not wasting non-renewable resources. The cost-effectiveness of current practices needs to be addressed and possible changes proposed to reduce costs and, ultimately, the social impact of all activities undertaken.

As can be seen from the above, sustainability in the management and maintenance of infrastructure has its own specifics that need to be implemented in sustainability documents, or the rules for meeting sustainability objectives need to be adapted to the conditions of a specific part of the national economy.

So the question is, what is sustainable maintenance anyway? Does sustainable maintenance fulfil the condition of cost-effectiveness? Is maintenance that respects the rules of sustainability more cost-effective than the practices currently in use?

The basic principle of maintenance is to look after the assets and liabilities entrusted so that they can be used repeatedly or for longer. However, this entails the use of a certain amount of material, money and energy, which can bring with it so-called externalities, i.e. unintended and dangerous by-products that can have a negative impact on the environment.

If sustainability is to be implemented in the current sustainability model and sustainable maintenance is to be introduced, the future environmental impacts of activities leading to the extension of product life cycles need to be estimated.

It is therefore necessary to select specific maintenance activities and assess their environmental impact, propose alternative, sustainable solutions and then assess the environmental impacts of the alternative solutions.

This approach is likely to show that there are situations where maintenance is less sustainable than new construction or replacement of an existing element than the less sustainable artificial

extension of the life cycle of that element under sustainable maintenance. This is likely to entail a need for a change in the strategic approach to sustainable maintenance.

It is therefore necessary to define and specify the basic maintenance criteria for sustainable infrastructure.

2. Sustainable development in the road maintenance sector

Sustainable development issues are dealt with by road sector organisations as part of their activities to make their operations more efficient. However, the strategic definition of economic objectives within the framework of sustainable development is currently not sufficiently linked to adequate management tools and methods that would allow the implementation of specific sustainable development requirements more easily in real time, as both the economy and transport are future-oriented, while measures to ensure sustainability in these areas are assumed to be based on the current state. The aim is therefore to identify appropriate tools, specifically in the area of strategic management, to enable future measures to be put in place to achieve sustainability.

Sustainable development is based on the historical human need not only to exploit but also to protect the environment necessary for life. However, in the context of the current approach, sustainability encompasses much more than this; it covers a range of areas where efficiency in management is required and can also help to address crisis situations through its tools.

However, the sustainable development of the national economy is not only a matter for the Czech Republic. The need to implement a sustainable approach has become significant in Europe and worldwide in recent years, and despite a number of measures taken, it can still be considered a long run.

According to the Ministry of the Environment, sustainable development is a type of future development of human society that aims to achieve harmony in economic and social progress with full preservation of the environment and opportunities to reap present benefits. At the same time, sustainable development aims to reduce or directly eliminate the negative effects of the past development of human society so that present opportunities are preserved for future generations. The reverberations of past and still receding approaches to resource use, based primarily on economic growth, have irreversibly affected the current shape of the planet and life on it. In the past, resources were used without regard for their finiteness and the impact of their use on the whole ecological system, and therefore to some extent to the detriment and debt of future generations, because society was primarily focused on economic growth, on the assumption that if capital (financial, natural, productive, material, social or human) shows growth, it is also sustainable. [12]

Prior to 2019, the Czech Republic was still struggling with a lack of resources in connection with the bark beetle calamity, followed by the global COVID-19 pandemic and related problems in

individual transport modes. First of all, there were problems in air transport, affected by restrictive measures, and then in maritime transport. Currently, there are increasing problems with delivery times, compliance with agreed terms and conditions and material security in the supply chain. All sectors, from healthcare to construction to the automotive industry, are currently facing material shortages. The shortage of materials makes what is available essentially a luxury good, but often only the price, not the quality, is the answer. At the moment, it is possible to speak unequivocally of a crisis that is unlikely to end any time soon. It is therefore necessary to start looking for other, alternative solutions. Many markets are still not functioning as they used to, deliveries are delayed by several months, which often affects the quality of the materials or goods supplied. The materials crisis has thus clearly become an economic crisis.

It is therefore necessary to bring about societal changes so that the current trend of endless growth with maximum use of limited resources is gradually changed into a process that will lead to maximum symbiosis between humans and the environment for the purpose of sustainability and increasing production. The way out of the crisis is through finding and implementing a sustainability tool that allows for a win-win solution where each party gives and receives. There is a need to replace the current linear model, which is unsustainable in the long term from the current perspective as it is based on the consumption of resources without regard to their renewability, with resources at the beginning of the economic process and products and waste at the end, with a circular model, which seeks to link the beginning and end of the cycle by trying to turn waste or a product at the end of its life into a full or at least partial resource again. The circular economy is therefore becoming a key tool for sustainable development.

3. Circular economy as a tool for sustainable development

The circular economy thus becomes one of the pillars of sustainable development, the essence of which is to increase the efficiency of production cycles and reduce the production of residual, i.e. no longer usable, waste. The circular economy is therefore concerned with the transformation of waste into additional resources and materials that can be recycled back into the various production cycles, despite the fact that there is as yet virtually no official definition of the concept.

The circular economy, often referred to as circularity in EU law, is a concept that is an integral part of sustainable development. The essence of the circular economy is to improve the quality of the environment and human life in general by increasing the efficiency of production. [12]

The Ellen MacArthur Foundation a British initiative seeking a global transition to a circular economy, defines the concept as an industrial system that is intentionally and by design regenerative and that through revitalisation replaces the concept of end-of-life products, moves towards renewable

energy sources, and aims to reduce waste through better design of materials, products, systems, and also business models. [12]

OECD states that circular business models represent fundamentally different ways of producing and consuming goods and services. They have the potential to stimulate the transition to a circular economy that uses resources more efficiently, thereby significantly reducing the environmental pressure resulting from economic activity. Circular business models also serve to reduce the extraction and use of natural resources and the generation of industrial and consumer waste. They represent the key activities needed to move towards a more resource-efficient circular economy. [21]

In general, the circular economy or circularity is a concept that aims to close the flows of materials and preserve their value in the economy for as long as possible. In theory, there is no waste as it serves as a resource for further secondary production. It is related to the concepts of reuse and recycle but seeks to encompass more broadly the main idea and principle of using all materials in production, not just for the production and recycling of the same product. It is further differentiated from traditional recycling by its emphasis on the product, components, materials and their reuse, refurbishment, remanufacturing as well as the use of renewable energy during the production and distribution of the product.

As stated by the European Commission such a concept will require significant involvement of the product design area as current estimates suggest that the design phase of a product will influence up to 80% of its environmental impact since products will already be designed to be reusable or suitably degradable for further production. The intention is to extend the lifetime of consumer goods and minimise the negative environmental impact of final disposal. From an economic point of view, it is about decoupling revenues from material inputs so that profits do not depend on the material intensity of production. The concept is called circular because it seeks to ensure that the material and energy flows of production are part of a single cycle in which all materials are used without waste. It is thus intended to replace the current linear model of production, in which natural resources are used to produce goods that are discarded after use ("take-make-dispose" model). [13]

3.1. Benefits of the circular economy

The introduction of the CE concept will reduce not only the extraction, but also the processing and disposal of materials. Furthermore, the reduced dependence on certain sources and inputs of materials, and the greater security of access to them that will be gained through the expansion of domestic secondary supplies, will have a positive impact for many importing countries in geopolitical crises and shocks. The positive environmental impact is also evident here as there will inevitably be a reduction in transport volumes.

As stated by the European Commission the correct and judicious use of circular economy principles can lead to a reduction in greenhouse gas emissions as recycled materials generate less than raw materials. Reduced demand for new goods due to extended product lifetimes and recovery rates can then lead to reduced emission characteristics. [13]

According to Ogunmakinde et al., the implementation of a circular economy would entail many activities that would promote job creation (as the value stored in the product is used as much as possible as well as retained in the economic cycle as long as possible) and overall growth of the economy. New opportunities will arise in the secondary manufacturing processing, repair, refurbishment, services and, not least, the sharing economy. [22]

Globally, Japan was the first country to enact circular economy principles. This was done as early as 1996, specifically in the form of the so-called resource efficient law, and was mainly aimed at managing resources, which are scarce in Japan.

Moreover, its geography is not very conducive to landfill, which was the second reason why Japan became a pioneer in recycling and the principle of reuse.

According to Ogunmakinde thanks to the enforced consumer responsibility to return electrical equipment, Japan is able to recover 74%-89% of materials. However, Japan's transition to a circular economy has been accompanied by effective collaboration between consumers and producers. [22]

By integrating the citizens, the economy and the social system through the optimal use of non-renewable resources and by making strategic changes towards renewable ones, Japan has succeeded in building a society that operates naturally on the principles of the circular economy. [22]

The top-down approach has clearly been applied, with the Japanese government creating a framework for the transition to a circular economy through the introduction of laws and regulations. [22]

3.2. Current status of circular economy in the road sector

In particular, public contracts, including road management contracts, relating to the recovery and subsequent recycling of construction and demolition waste, or the use of recyclates in construction, represent a major potential for circular procurement.

According to the Czech Statistical Office, construction and demolition waste consists of almost 40% concrete and concrete products, 33% metals, more than 10% asphalt mixtures and less than 7% bricks. The use of this type of waste is one of the fundamental pillars for achieving raw material sufficiency. [8]

Construction and demolition waste can be used in the road construction industry not only for low-end use as subbase, backfill or embankments, but also as aggregate for concrete.

For concrete, according to the current standard ČSN EN 206 +A1, it is possible to replace a maximum of 50% of the coarse aggregate fraction with recycled concrete type A, while 100% replacement is not permitted and the standard does not allow for the replacement of sand with recycled crushed mix.

However, recycled masonry can be used for concrete in dry masonry applications such as retaining walls or dry material cubicles. It is also possible to use glass in the concrete mix. [24]

Table 1 R-material dosage options according to ČSN 736120 Source: [24,25]

Type of Mixture	% w/w of R-material by dosage method		Note
	Preheated	Not Preheated	
VMT – bedding layer	25 %	20 %	<p>A dosage of R-material greater than 15 % w/w (inclusive) must be applied:</p> <ul style="list-style-type: none"> – either a higher gradation binder - softer asphalt binder (an increase of one gradation class is permissible, i.e. when using road asphalt it is permissible to use road asphalt 50/70 in the asphalt mix of VMT with R-material); – or the use of a suitable revitalising agent (rejuvenator); – or PMB RC according to ČSN 65 7222-1.
VMT – base layer	40 %	20 %	
SMA L	30 %	15 %	For R-material dosage higher than 15 % w/w (inclusive), a suitable rejuvenator or PMB with additional RC designation in accordance with ČSN 65 7222-1 must be used.
ACP RBL	40 %	20 %	When the dosage of R-material is higher than 15 % w/w, either a higher gradation binder must be applied or a suitable rejuvenator or PMB with additional RC marking must be used in accordance with ČSN 65 7222-1.
AC Z +	40 %	20 %	When the dosage of R-material is higher than 15 % w/w, either a higher gradation binder must

AC Z	70 %	20 %	be applied or a suitable rejuvenator or PMB binder with additional RC marking must be used in accordance with ČSN 65 7222-1.
SAL	0 %	0 %	

The wood can be used for the production of fibreboards, paper as reinforcement for lightweight skeleton partitions. Another possibility of use relates to asphalt mixes, which are listed in the implementing standards ČSN 73 6121 of 2019 and ČSN 73 6120 of 2021. The percentage of recycled material varies from mix to mix, but in general it can be said to be between 15 - 60%, as shown in the Table. However, these are only a few examples of the use of recyclates. The current trend in this area is to achieve zero waste in road construction within a few years. [25]

Should contracting entities decide to embrace the use of secondary raw materials, they can create pressure on the market for products and services that increasingly use innovative or circular solutions. With current support from the state or the EU, the implementation of a circular economy could be achieved in a step-by-step approach. The current trend of circular economy in the roads sector is that no waste should be removed from construction sites in the next few years, and from a practical point of view this is a trend that can be achieved.

3.3. Circular economy and its legislative framework

Sustainable development is based on the historical human need not only to exploit but also to protect the environment necessary for life. In the context of the current approach, however, sustainability encompasses much more than this; it covers a range of areas where efficiency is required in management, access and governance, not least the national economy.

However, the sustainable development of the national economy is not only a matter for the Czech Republic. The need to implement a sustainable approach has become significant in Europe and worldwide in recent years, and despite a number of measures taken, it can still be considered a long run.

According to the Ministry of the Environment, sustainable development is a type of future development of human society that aims to achieve harmony in economic and social progress with full preservation of the environment and opportunities to reap present benefits. At the same time, sustainable development aims to reduce or directly eliminate the negative effects of the past development of human society so that present opportunities are preserved for future generations. The reverberations of past and still receding approaches to resource use, based primarily on economic growth, have irreversibly affected the way the planet and life on it function today. Resources have

been used in the past without regard to their finiteness and the impact of their use on the whole ecological system, and therefore to some extent to the detriment and debt of future generations. [9]

In order to achieve truly sustainable development, this approach needs to be changed and current public policies in all their forms, be they legislative, strategic or economic, need to be replaced by cohesion policies, or future sustainability for all. Sustainable development goals apply to all countries, and each of them can therefore contribute to their achievement to some extent.

It is therefore essentially about setting up societal changes so that the current trend of endless growth with maximum use of limited resources is gradually changed into a process that will lead to maximum symbiosis of humans and the environment for the purpose of sustainability and increasing production. The aim is therefore to find and implement a win-win solution where each party gives and receives. It is therefore a matter of replacing the linear economic model, which is unsustainable in the long term from the current point of view, as it is based on the consumption of resources without regard to their renewability, with resources at the beginning of the economic process and products and waste at the end, with a circular model, which seeks to link the beginning and the end of the cycle by trying to make the waste or the product, at the end of its lifetime, fully or at least partially a resource again.

3.4. Sustainable Development and Circular Economy

The circular economy has thus become one of the pillars of sustainable development, the essence of which is to increase the efficiency of production cycles and reduce the production of residual, i.e. no longer usable, waste. The circular economy is therefore concerned with the transformation of waste into additional resources and materials that can be recycled back into the various production cycles, despite the fact that there is as yet virtually no official definition of the concept.

According to EurLex, the circular economy, often referred to as circularity in EU law, is a concept that is an integral part of sustainable development. The essence of the circular economy is to improve the quality of the environment and human life in general by increasing the efficiency of production. [1]

The Ellen MacArthur Foundation, a British initiative seeking a global transition to a circular economy, defines the concept as an industrial system that is intentionally and by design regenerative and that through revitalisation replaces the concept of end-of-life products, moves towards renewable energy sources, and aims to reduce waste through better design of materials, products, systems, and also business models. [29]

OECD says that circular business models represent fundamentally different ways of producing and consuming goods and services. They have the potential to drive the transition towards a more resource efficient and circular economy and, in doing so, significantly reduce the environmental

pressure resulting from economic activity. Circular business models may also serve to reduce the extraction and use of natural resources and the generation of industrial and consumer wastes. They represent the key activities required to transition to a more resource efficient and circular economy. [21]

As Kircher, Reike and Hekkert state in their study, a search of different approaches to defining the circular economy has yielded one possible comprehensive definition. According to this study, the circular economy is an economic system that replaces the concept of a product's finite life cycle through the reduction of materials or, alternatively, their reuse, repair or recycling in the production, distribution and consumption process. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, state and beyond), with the aim of achieving sustainable development, i.e. the simultaneous pursuit of environmental quality, economic prosperity and social equity, for the benefit of present and future generations. However, all this is only possible in the mutual cooperation of newly conceived economic models and responsible consumers. [23]

Many authors consider the 3R framework referring to Reduce, Reuse and Recycle activities as the core of the circular economy. The application of 3R principles can be achieved by redesigning and reordering urban infrastructure and industrial layouts, along with the decommissioning of heavily polluting businesses. Another concept of CE emphasises the importance of separating production into two cycles - the biological and the technical. Consumption takes place primarily in the biological cycle, in which organic material and food is returned to the system through processes such as composting or anaerobic digestion. In the technical cycles, products, components and materials are repaired and renewed through processes of reuse, remanufacturing, remanufacturing or recycling. [21]

The concept of circular economy is based on fragments and ideas from several scientific disciplines and concepts - industrial ecology, eco-efficiency, biomimicry (mimicking solutions in nature), cradle to cradle design (functional materials even after the end of the product's lifetime), performance economy (an economy with an emphasis on services related to the maintenance and use of material stocks), natural capitalism and others. [23]

This is also one of the reasons why it is necessary to set the design of products and materials with a life cycle that is safe for health and the environment and that can be sustainably reused through biological and technical metabolism. In general, therefore, the circular economy or circularity is a concept that aims to close the flows of materials and preserve their value in the economy for as long as possible. In theory, there is no such thing as waste, as it serves as a resource for further secondary production. It is related to the concepts of Reuse and Recycle but seeks to encompass more broadly the main idea and principle of using all materials in production, not just for the production and

recycling of the same product. It is further differentiated from traditional recycling by its emphasis on the product, components, materials and their reuse, refurbishment, remanufacturing as well as the use of renewable energy during the production and distribution of the product. [29]

As stated by the European Commission, such a concept will require significant involvement of the product design area as current estimates suggest that the design phase of a product will influence up to 80% of its environmental impact since products will already be designed to be reusable or suitably degradable for further production. The intention is to extend the lifetime of consumer goods and minimise the negative environmental impact of final disposal. From an economic point of view, it is about decoupling revenues from material inputs so that profits do not depend on the material intensity of production. The concept is called circular because it seeks to ensure that the material and energy flows of production are part of a single cycle in which all materials are used without waste. It is thus intended to replace the current linear model of production, in which natural resources are used to produce goods that are discarded after use ("take-make-dispose" model). [15]

One of the benefits of the circular economy is that the introduction of the CE concept will help to reduce not only the extraction, but also the processing and disposal of materials. In addition, the reduced dependence on certain sources and inputs of materials and the greater security of access to them that will be gained through the expansion of domestic secondary supplies will have a positive impact for many importing countries in geopolitical crises and shocks. The positive environmental impact is also evident here, as there will inevitably be a reduction in transport volumes and, as a consequence, a reduction in the volume of roads sector work.

The correct and judicious use of circular economy principles can lead to a reduction in greenhouse gas emissions, as recycled materials generate less than raw ones. The reduced demand for new goods due to the extension of product lifetimes and recovery rates will then lead to a reduction in emission characteristics. [29]

Inappropriate implementation of circular economy principles in the form of excessive use of renewable energy as one of the last steps in the cycle before product, biofuel and biomaterial removal may in turn lead to a worsening of the changing climate situation. [18]

The implementation of a circular economy entailed many activities that would promote job creation (as the value stored in the product is used as many times as possible, as well as retained in the business cycle for as long as possible) and overall economic growth. New opportunities will arise in the sectors of secondary manufacturing, repair, refurbishment, services - especially in the sharing economy. [15]

The transition from a linear model to a circular model, however, brings with it certain pitfalls. One of the pitfalls of implementing circular economy principles is the neglect of the social pillar. A common mistake is the absence of mentioning benefits for future generations as a key element of

the aforementioned sustainability. Yet including long-term and sustainable benefits in discussions on the circular economy is essential if stakeholders are not to lose interest in the concept. In general, the circular economy gives more space to technological solutions to sustainability, without considering its ability to adapt to technological change from a social point of view, as well as its demands on material resources. It is therefore important to maintain a cohesive approach. [23]

Friant, Vermeulen and Salomone state that another pitfall of implementing the circular economy concept is its inconsistency and lack of concreteness. Different individuals and sectors shape circular discourses that are congruent with their interests, but which often do not further explore the ecological, social and political implications of circularity in a broader context. The concept thus acts more as a means of greenwashing, i.e. disinformation that creates an environmentally responsible image of society. [30]

Another pitfall of the circular economy concept is the de facto impossibility of a perfectly closed production cycle from a thermodynamic point of view, as materials degrade both quantitatively and qualitatively with each successive cycle or use. It is therefore clear that in order to achieve a functional circular economy, it is also necessary to reduce material demand together with economic output, and therefore to achieve cooperation in this direction from the demanders. Indeed, energy plays a central role in the circular economy. In accordance with the principles of the concept, this should be obtained from renewable sources. However, these are not yet sufficient to cover all consumption, and the introduction of the circular economy will therefore require the expenditure of large amounts of material resources to build additional related infrastructure. [30]

This also opens up a very interesting part of the circular economy, which is the sharing economy. By sharing and renting, it is possible to replace ownership and therefore to make savings. In addition, the sharing economy is production and service oriented, and therefore aimed at maximising the potential of the product, with the costs associated with this being borne by a much larger number of users.

3.5. Legislative framework of the Circular Economy

The areas of investigation can be divided into three parts. The first is the global perception of the circular economy, the second concerns the European Union and its legislation and the third part will be devoted to the perception of the circular economy in the Czech Republic.

According to the European Commission, the concept of circular economy dates back to 1960, when there was an increased interest in environmental protection and more environmentalists, economists and especially consumers started to take up the issue. Businesses responded to this situation in the 1970s by introducing the concept of corporate social responsibility. [15]

Globally, Japan was the first country to enact circular economy principles. This was done as early as 1996, specifically in the form of the so-called resource efficient law, and was mainly aimed at managing resources, which are scarce in Japan. Moreover, its geography is not very conducive to landfilling, which was the second reason why Japan became a pioneer in recycling and the principle of reuse.

The recovery of electrical equipment in Japan is 74%-89% of materials thanks to the enforcement of consumer responsibility. However, Japan's transition to a circular economy has been accompanied by effective collaboration between consumers and producers. By integrating the citizens, the economy and the social system through the optimal use of non-renewable resources and by making strategic changes towards renewable ones, Japan has succeeded in building a society that operates naturally on the principles of the circular economy. The top-down approach has clearly been applied, with the Japanese government creating a framework for the transition to a circular economy through the introduction of laws and regulations. [22]

The experience of implementing CE principles in Japan has been followed by some other countries such as China and Germany. However, even in these cases, the implementation of the circular economy would not have been possible without appropriate policies. These include, on the one hand, a ban on landfilling, extended producer responsibility or a take-back scheme, and on the other hand, facilitating and promoting the collection of used materials and products and budgeting the costs of take-back and product recovery into the cost of a new product. [22]

Another example of a country that is taking the legislative route in implementing the circular economy is France, where a law on waste reduction and the circular economy came into force in 2020. Its purpose is to reduce waste generation, reduce plastic pollution and protect the environment, avoid waste and promote the reuse of goods already produced by gradually introducing measures. The law has an impact on the daily life of the population, but also affects private companies from all sectors and public institutions. France thus presents the transition to a circular economy as an opportunity, particularly for companies offering alternatives to single-use plastics and plastic packaging materials, and more broadly for companies offering technological solutions for waste sorting and better processing and reuse. France is thus building on the European Union's policy of viewing the circular economy as a priority issue, as it provides opportunities for material self-sufficiency, creates new jobs and opens up space for investment in sustainable innovation.

3.5.1. Legislative framework for the Circular Economy in the European Union

The circular economy, also known as circularity, is addressed at EU level by Directive 2008/98/EC on waste and subsequently extended by amending Directive 2018/851. The latter already introduces circular economy concepts into legal practice and promotes sustainable production and

consumption patterns, material efficiency and eco-innovation in order to move towards a modern, competitive and resource-efficient economy. [4]

According to the European Commission, up to half of greenhouse gas emissions and more than 90% of biodiversity loss in EU countries are caused by resource extraction and processing. Recognising the need to change the current economic paradigm and move towards a circular economy, the European Union is choosing, like China and Japan, to incorporate circular economy principles into its legislation. [7]

As mentioned above, the 2008 Waste Directive already introduced the so-called waste hierarchy, which essentially expresses the basic principle of the circular economy. The waste hierarchy of this Directive refers to the activities related to waste management and the order in which the different steps are to be applied. The most desirable objective, therefore, placed at the base of the pyramid, is prevention or avoidance of waste. Each Member State was obliged to draw up a plan within five years of the aforementioned directive on how it would implement this prevention step.

According to the European Commission, between 2011 and 2015, the EU Generation Awake campaign highlighted waste-related issues. In 2014, the European Commission issued a communication on the so-called circular economy entitled "Towards a circular economy: A zero waste programme for Europe", with the European Commission planning for Europeans to recycle 70% of municipal waste and 80% of packaging waste by 2030. Subsequently, the EU published the Roadmap to a Resource Efficient Europe and the Zero Waste Programme for Europe. Under these, the EU was already trying to steer the economy in a more sustainable direction, for example through its eco-design requirements, which set maximum energy consumption for certain products or minimum amounts of recycled material needed for production. The eco-label tool then allows companies that meet strict environmental criteria to act as a responsible producer on the market. In 2015, the EU issued packages on these documents that aimed to accelerate the transition of European economies to a circular economy. They mainly address waste, landfill and packaging. [7]

In addition, the European Commission released a Circular Economy Action Plan, which contained 54 measures to support the circular economy, which were implemented in 2019. For example, the EU Plastics Strategy is part of the plan, which aims to achieve full recyclability or reusability of plastic packaging by 2030. Another Circular Economy Action Plan was released in 2020, aiming to target the most resource-intensive sectors. [12]

As reported by the European Commission, €7.1 billion was earmarked under the 2014-2020 Cohesion Policy, which included the circular economy as a priority after a delay. For the same period, Horizon 2020 was announced as the most important EU programme to support research and innovation. Among other things, it was intended to serve as an incentive for innovation in the circular economy, for example offering €650 million in support for circular projects in 2017 alone. [14]

According to the European Commission, another support mechanism for the circular economy is green public procurement, through which public institutions in the EU can provide significant support for environmentally desirable projects. By opting for green procurement, the public sector can not only support EU environmental and cohesion policy, but can also achieve savings itself, for example in the form of lower energy costs when investing in energy efficient equipment or savings in the disposal of hazardous substances in products when purchasing those that do not contain them. [15]

The European Commission further states that the construction sector, which generates about 35% of all waste, consumes half of all extracted resources, half of all energy and a third of all water in the EU, has a voluntary Level(s) framework with indicators to help assess the environmental impact of construction. The purpose is to foster a responsible approach to construction and its life cycle among builders. [15]

The European Commission also mentions the ETV (Environmental Technology Verification) tool, which aims to support innovative green technologies, especially at market entry. The ETV allows the European Union to provide confirmation of the reliability and environmental benefits of a new technology, thus increasing its credibility in the market. [15]

Another EU support tool, according to the European Commission is the Eco-Management and Audit Scheme (EMAS) under which companies can improve their environmental impact not only by implementing the principles of the 3Rs, but also by demonstrating this as a responsible company. [15]

According to the European Commission, in the course of 2019 the EU published an updated version of the proposal for a Directive on the reduction of single-use plastic products and their impact on the environment (SUP), which was subsequently endorsed by the European Parliament and the Directive was subsequently approved by the Council. [14]

According to the European Commission, on the initiative of the EC and the European Economic and Social Committee, the European Circular Economy Stakeholder Platform was created to promote the concept of the circular economy in Member States, regional and local authorities, civil society and businesses, with the aim of strengthening cooperation between stakeholders and facilitating the exchange of expertise and best practices. Then, in December 2018, the Circular Plastics Alliance was established to accelerate Europe's transition to a circular economy, targeting sectors with the highest demand for plastics, such as packaging, construction and automotive. [13]

3.5.2. Legislative framework of the Circular Economy in the Czech Republic

The legislative framework for the circular economy in the Czech Republic will largely correspond to the EU legislative framework. However, there are major differences between EU and Czech legislation. It is therefore necessary to clarify the role of the state in the transition to the circular economy. It is clear from the above that the state should primarily motivate on the one hand and not

impose obstacles on the other. On the one hand, the state can motivate through a range of instruments, such as various incentives, subsidies and support. On the other hand, it should focus on creating legislation that will not hinder circular economy models if it is not possible for it to be drafted primarily in a supportive manner.

As Pavel Telička (2020) states in his booklet *Circular Czechia*, for a successful transition to a circular model we need clear policies, good legislation and a business environment that supports innovation. [30]

The interest in the principles of the circular economy has inevitably manifested itself in the Czech Republic as an EU member state and, at the same time, increasingly in the private sphere of businesses, companies and think tanks dealing with technology and innovation. As a country whose economy is largely based on industry, the Czech Republic seems to be aware of the urgency of the problem of the depletion of material resources.

The principle of the circular economy is simple, it is about consciously reducing waste production and using more renewable resources instead of limited ones. The aim is therefore to avoid waste and to prioritise recycling, product repair and reuse of raw materials and products.

To promote the circular economy, the Institute of Circular Economy was established in 2015 in the Czech Republic, which focuses on educational and practical activities aimed at the application of the circular economy and the analysis of waste monitoring. Here, therefore, it is a support mechanism from the private sector, as environmental legislation in the Czech Republic creates constant pressure to find new solutions that should be both economically viable and environmentally friendly, and the public sector is not proving sufficiently flexible in this area. [30]

In the public sphere, the Ministry of the Environment (ME) and the Ministry of Trade and Industry (MTI) are the main actors involved in the implementation of circular economy principles in the Czech economy, while the Czech Statistical Office (CSO) is responsible for collecting data on business expenditure on environmental protection related to the use of the circular economy model.

In the context of the circular economy, the Ministry of Industry and Trade (2020) deals primarily with material resources, their secondary use and energy, in documents such as the State Energy Concept or the Secondary Raw Materials Policy for the period 2019-2022. With regard to the promotion of entrepreneurship and innovation, the Ministry of Industry and Trade organises an annual competition for the best circular project *Waste to Resources*. Several interesting projects have already been presented in the categories of private businesses, as well as municipalities, schools and others. [16]

As part of its support activities within the circular economy, the Ministry of Industry and Trade has created a *Catalogue of Products and Materials Containing Secondary Raw Materials for Use in*

the Construction Industry, which is available online and contains an overview of basic concepts and materials with potential for use in the construction industry within the circular economy.

In addition, according to the Ministry of Industry and Trade, a Methodological Guide of the Waste Department for the management of construction and demolition waste generation and management was created in 2018, as well as, in cooperation with the Czech Standardisation Agency, a Catalogue of Products and Materials Containing Secondary Raw Materials, which has two parts: an overview of secondary raw materials and an overview of recycled products with technical standards and all legislative measures and legal documents. [16]

Issues related mainly to waste and waste management fall within the competence of the Ministry of the Environment in terms of the circular economy. To this end, the Ministry of the Environment has developed a Waste Management Plan for the period 2015-2024 and a Waste Prevention Programme, which each EU Member State must draw up on the basis of the above-mentioned Directive. [16]

The Ministry of the Environment states that it has developed a unified strategy for the circular economy in cooperation with the OECD called the Strategic Framework for the Circular Economy of the Czech Republic 2040, or Circular Czech Republic 2040 for short. According to the Ministry of the Environment (2021), this is a long-term overarching strategic document for strengthening the principles of the circular economy in the Czech Republic, which emphasises the circular economy as a priority for the Czech Republic. Its aim is to present the direction of the development of the circular economy in the Czech Republic until 2040. The document contains several priority areas, such as Industry, Raw Materials, Construction and Energy, Waste Management, Circular Cities and Infrastructure, Education and Knowledge, Economic Instruments and Research, Development and Innovation. [18]

In response to the mitigation of the impacts of the COVID-19 pandemic, the Ministry of Environment (2021) has created a National Recovery Plan, a plan for the recovery and resilience of the country. The plan is based on the NextGenerationEU instrument and is mainly reform-oriented compared to the conventional cohesion instruments. Its aim is therefore economic recovery, but not through investment, but through reforms that would help improve the environment in the Czech Republic and build a new, more resilient society to become more competitive and sustainable. Here, too, there is significant scope for the introduction of circular economy principles.

Within the construction sector, the Ministry of the Environment issued the Methodological Guidance of the Waste Department of the Ministry of the Environment for the management of construction and demolition waste. This is because a large amount of construction-related waste is generated in the Czech Republic every year and only a small part of it can be reused according to the regulations, as will be discussed below. [17]

3.5.3. Circular Economy in the roads sector

In the Green Deal for Europe, the European Commission has emphasised the application of circular economy and resource efficiency principles in the construction sector with the aim of reducing the future use of primary natural resources. In this context, the EU Protocol on Construction and Demolition Waste Management promoting the circular economy and increasing the efficient use of natural resources in the construction sector has also been issued, which seeks to put forward a set of principles for sustainable building design to prevent and reduce construction and demolition waste, facilitate the reuse and recycling of building materials, products and building elements, and thereby help mitigate the environmental impacts and life cycle costs of buildings. [15]

In particular, public contracts, including road contracts, relating to the recovery and subsequent recycling of construction and demolition waste, or the use of recyclates in construction, represent a major potential for circular procurement.

According to the Czech Statistical Office, construction and demolition waste consists of almost 40% concrete and concrete products, 33% metals, more than 10% asphalt mixtures and less than 7% bricks. The use of this type of waste is one of the fundamental pillars for achieving raw material sufficiency. [8]

In construction and infrastructure building, it is possible to use waste in the production of recyclates, which is, among other things, determined by the applicable ČSN standards. [24]

Construction and demolition waste can be used in the road construction industry not only for low-end use as subbase, backfill or embankments, but also as aggregate for concrete. For concrete, according to the current standard ČSN EN 206 +A1, it is possible to replace a maximum of 50% of the coarse aggregate fraction with recycled concrete type A, while 100% replacement is not permitted and the standard does not allow for the replacement of sand with recycled crushed mix. However, recycled masonry can be used for concrete in dry masonry applications such as retaining walls or dry material cubicles. It is also possible to use glass in the concrete mix. [25]

Wood can be used for the production of fibreboards, paper as reinforcement for lightweight frame partitions.

Another possibility of use concerns asphalt mixtures, which are listed in the implementing standards ČSN 73 6121 of 2019 and ČSN 73 6120 of 2021. The proportion of recycled material varies from mix to mix, but in general it can be said to be between 15 and 60%. [25]

And these are just a few examples of the use of recyclates. Should contracting entities decide to embrace the use of secondary raw materials, they can create pressure on the market for products and services that increasingly use innovative or circular solutions. With current support from the state or the EU, the implementation of a circular economy could be achieved in a step-by-step approach. The

current trend of circular economy in the roads sector is that no waste should be removed from construction sites in the next few years, and from a practical point of view this is a trend that can be achieved.

However, it would be wrong to confuse the term circular economy with the term recycling economy. The main benefit of the recycling economy is recycling, which is not in itself a viable tool for waste management in the future. It is an energy-intensive process that cannot be applied to all products. In many cases, it is not recycling, but downcycling, where the original product is not partially or completely recovered but is partially or completely used to create another product, since the material loses its original properties through recycling. The principle of the circular economy is to strive to preserve value at all stages of the life cycle, whether it is resources, products, their renewal, repair, refurbishment or reuse. In the case of the circular economy, we can talk about regeneration rather than recycling. Recycling is therefore only one of the tools of the circular economy, and the main objective of the circular economy is to produce a product that is of the highest quality, has the longest possible lifetime and is as waste-free as possible, with as little non-renewable resources and energy as possible being used in its production. However, this will only be achieved if there is a matching of supply and demand sides with current legislative and other support from the state and the European Union.

The intention of this thesis is to apply Risk Management to the specific conditions of an organization operating in the area of management and maintenance of lower category communications and to find ways to make the organization's activities more efficient so that they meet the conditions of sustainability and therefore can lead to social responsibility.

The basic hypothesis in this contribution is "Using risk management tools can achieve efficiency and thus contribute to the sustainability of social responsibility in the conditions of an organization dealing with road management."

4. Risk analysis of the fulfilment of asset management objectives in roads sector in the context of circular economy with focus on the level of regions of the Czech Republic

With regard to the roads sector, the nature of the activity is that of securing infrastructure assets. A certain extent of the network at the level of individual regions also falls within the critical infrastructure of the State. This gives rise to requirements to ensure adequate condition and serviceability.

If we consider the definition of the circular economy in accordance with the study by Kircher, Reike and Hekkert, according to this material, *the circular economy is supposed to be an economic system that replaces the concept of the final life cycle of a product through the reduction of materials*

or alternatively their reuse, repair or recycling in the process of production, distribution and consumption. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, state and beyond), with the aim of achieving sustainable development, i.e. the simultaneous pursuit of environmental quality, economic prosperity and social equity, for the benefit of present and future generations. However, all this is only possible in the mutual cooperation of newly conceived economic models and responsible consumers. [23]

In relation to the above, activities related to the roads sector can be considered as an agenda supporting the activities of regional and municipal authorities in the field of state administration in road matters conducted by the relevant road administrative authorities.

The road infrastructure is the basis for the continued functioning of the economy in the area. It can be compared to a "bloodstream", without which a territory with insufficient transport infrastructure services would fall behind.

This also implies the necessity of continuity in ensuring the required extent of the road network in the required quality.

Thus, it cannot be a "finite life cycle" concept, but an inherently "circular process" of management, maintenance, investment and governance.

A separate chapter is the position of "consumers", which can be perceived on several levels:

- the consumer as an ordinary user of the infrastructure, but also
- the consumer as a customer (or the founder of the relevant organisation), or
- the consumer as a specific user.

An ordinary user is a natural or legal person using the road in accordance with the provisions of the relevant legal standards. Typically law relating to road traffic.

The founder is the entity creating the conditions for the establishment of the organisation and setting the rules for its functioning. The financial flows flowing into the established organisation and their destination are substantially related to this position. One of the functions of the founder is also to communicate with the institutions in charge of the state budget chapters from which funds may flow into the infrastructure, but also with institutions managing extra-budgetary resources.

The specific user is other entities using the infrastructure on the basis of other standards. These include, for example, the transport of oversized loads, or the use of the infrastructure in the context of ensuring the basic functions of the state in declared states of emergency management.

It follows from the above that it is necessary to take a comprehensive approach to the roads sector, including risk assessment. Risks are the dynamically changing factors that affect the

achievement of the organisation's basic objectives of ensuring the roads sector management in the defined region.

If we talk about the dynamics of the development of factors, their temporal effects must not be overlooked.

The specificities of the roads sector, and of the durable goods sector in general, lie in the postponement of the impact of measures taken or not taken. Investment or maintenance will have a relatively immediate effect, whereas postponing the implementation of such actions has the following consequences:

- immediate (relative) financial savings, and
- cumulative degradation of infrastructure.

In the last few years, the rise in the price of construction work and materials has also had a significant impact.

However, the relative saving of funds that will occur if the investment action is postponed will be reflected in the subsequent increase in the demand for financial resources. The degradation of infrastructure is not only cumulative, but also increases disproportionately. Depending on the increase in axle load, the deterioration of the road increases up to a cubic dependence.

When assessing the current state of quality of lower-class roads (II and III), according to various sources, the neglect in maintenance is due to underfunding to the extent of more than 70% in some parts of the road network. These are sections characterised as 'substandard' and sections in 'state of disrepair'. According to studies (e.g. by the World Bank), the road classes were already underfunded by more than 50% in about 2010, and there has been further deterioration.

In the context of the above, and in relation to the philosophy of the circular economy, two basic concepts of infrastructure maintenance can be considered:

- "Ad hoc" maintenance,
- cyclical maintenance.

In a figurative sense, cyclical maintenance represents a certain way of preventing emergency road conditions and is applied, for example, in some sections under the responsibility of ASFINAG in Austria.

Currently, however, the ad hoc approach is generally used in the Czech Republic, which depends on the availability of financial resources, which are insufficient in the long term. From a longer-term perspective, we are therefore in a situation where not only is cyclical maintenance impossible, but also the ad hoc principle is not sustainable in the long term.

If the societal goal is to have a quality infrastructure, it is necessary to deal methodologically with the way it is maintained, i.e. the choice of approach, but also the risks involved. There are

undoubtedly many of these, which is why it is necessary to concentrate on 'risk management', to carry out a risk analysis and to focus on the most serious risks.

It is not about the concept of risk within the function of the organisation itself, where the actual system is implemented, but about the level of risk above the organisation itself, in which external factors are also considered.

An organisation engaged in the management and maintenance of Class II and III roads is exposed to internal and external influences creating uncertainty in achieving the set objectives. It is the impact of this uncertainty that can be described as risk. The need to manage risks is determined not only by the general requirements for proper performance in terms of corporate governance, but also by legal standards. One possible approach is the so-called centralised risk management system. Its advantages lie in its high efficiency in risk management and in ensuring the stable operation and development of the organisation. Provided, of course, that the parameters are set correctly.

The system can be implemented using the ISO 31000 (Risk Management) standard. It recommends, among other things, to implement the risk management process in the organisation at the level of overall leadership, strategy, planning, management, processes, reporting, policies, values, and culture of the organisation. External factors are considered but cannot be directly addressed by the organisation.

At the same time, it is clear that a large number of activities related to risk management are also carried out informally as part of the day-to-day activities in various departments of the company, policies, and the organisation itself. At the same time, these activities are also an integral part of the management process.

As regards the legal subtext, it is necessary to mention in particular Act No. 93/2009 Sb., on Auditors, Act No. 320/2001 Sb., on Financial Control, as well as the increasingly topical Act No. 181/2014 Sb., on Cyber Security, and others. Risk management, in terms of methodologies, principles and procedures, is addressed, for example, by the already mentioned ISO 31000 or ISO 31010, or "A Risk Management Standard", which is discussed by the Institute of Risk Management, FERMA (Federation of European Risk Management Associations), and others. [30,31]

Much of the above material discusses risk from an operational, operational perspective, but when assessing the assurance of the organisation's function, it is necessary to take a certain detached perspective and view risks as factors influencing the organisation's strategy.

From this point of view, the influence of external factors that cannot be influenced by the organisation, but must be respected and considered, as well as the time overlap of typically one accounting period or one season (typically, for example, the winter maintenance situation) must also be considered.

For future work, we will consider risk as "a source of hazard that has the active property of adversely affecting the roads sector".

However, the principles of risk management are similar.

Thus, in terms of chronology (including the feedback loop), the following steps can be defined:

- Risk identification (i.e. identification of all significant sources of risk with the potential to affect the achievement of the objective or task);
- risk analysis (complex risk analysis; analysis of individual risks in terms of its probability of occurrence);
- risk assessment (evaluation; an assessment of the relevance of the risk and an expression of its potential severity);
- identification of the owner (including definition of the entities concerned);
- dealing with risk and corrective actions (defining the risk holder; determining corrective actions and reporting);
- preventive measures and monitoring (determining feedback and information flow).

[32,33]

These sequences are based on the general principles of risk analysis but have been adapted to the specific needs of strategic roads management.

This is not simply the performance of an activity that is the responsibility of a state-funded organisation, but a strategic view of the area. [34]

According to various methodologies, risk management consists of phases spread over 3 to 8 steps. However, some of them are intertwined and methodologically focused on the operational aspects of the organisation's activities. The above breakdown has therefore been established. In fact, in practice, there are often situations where duplication leads to confusion and repetition of information, creating problems of ambiguity. This can be explained both in terms of the level of responsibility and, above all, the impact on possible corrective action. [35]

Accordingly, a selection of significant risks has been made, with their evaluation and expression of the level of risk. The risk level is based on an assessment of the impact of the risk and the likelihood of its occurrence.

The risk impact (RI) scale is selected in five levels: very low risk (1); low risk (2); medium risk (3); high risk (4); very high risk - critical (5).

The risk probability (RP) is defined on a scale consisting of five levels: minimal risk (1); exceptional risk (2); common risk (3); probable risk (4); risk bordering on certainty (5).

The risk level (RL) is then expressed as the product of the risk impact and the probability of its occurrence. Thus: $RL = RI \times RP$.

The risk value is then divided into five levels: minimal risk ($RL < 5$); low risk ($5 \leq RL < 10$); moderate risk ($10 \leq RL < 15$); high risk ($15 \leq RL < 20$); extreme risk ($20 \leq RL$).

The graphical representation of the interdependence of risk impact (RI) and risk probability (RP) can then be illustrated by considering the risk value or risk level (RL), as the case may be, in the following figure. The level of risk is indicated under each heading.

		5	10	15	20	25
Risk Probability (RP)	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Risk Impact (RI)				

Figure 1 Risk map Source: Author

This process has defined the risks related to the approach to securing the roads sector in the form of “Ad hoc” and “Cyclical” maintenance.

In addition to the risk definition, the entity under whose responsibility the risk falls is also identified. From the whole range, the 10 most serious risks were defined and subsequently dealt with. The risks were defined using a brainstorming exercise, with a team of managers whose responsibility includes road management issues.

For each scenario, an overview table with a risk map is presented containing the number of defined risks in each segment. Although in some cases the same risks are defined, they differ in their likelihood of occurrence. This affects the overall level of risk.

The likelihood of occurrence is determined by differences in the approach to securing the roads sector.

Table 2 Ad Hoc Maintenance Source: Author

Risk - Name	Risk Owner	Risk Impact (RI)	Risk Probability (RP)	Risk Level (RL)	Note
Stability of allocated funds at the level of regions and municipalities	region	5	4	20	
Under-maintained infrastructure	region; administrative organisation	5	5	25	Risk of further deferral of maintenance and associated increase in under-maintenance
Compliance with the expected scope and timetable of individual actions	administrative organisation; contracting parties	4	4	16	
Occurrence of additional/supplemental work	administrative organisation	3	3	9	Matter of selection of construction contractors
Errors in the planning of construction activities	administrative organisation	4	4	16	In the case of ad hoc maintenance, the probability of risk is higher due to the requirement for

					higher operability
Mutual cooperation between entities (authorities; institutions; other actors)	administrative organisation; other entities	3	3	9	
Staffing of the organisation's activities	administrative organisation	3	3	9	
Implementation of winter maintenance according to legislative requirements and set plans	administrative organisation	4	3	12	
Construction work prices (including materials)	market	4	3	12	
Energy prices (taxonomy implications)	EU	3	3	9	Change in concept of "clean" energy source; impacts on allowance prices; shorter planning time considered in ad hoc solution

Figure 2 showing the number of risks in each segment.

Risk Probability (RP)	5					1
	4				2	1
	3			4	2	
	2					
	1					
		1	2	3	4	5
		Risk Impact (RI)				

Figure 2 Risk map Source: Author

Table 3 Cyclic Maintenance Source: Author

Risk - Name	Risk Owner	Risk Impact (RI)	Risk Probability (RP)	Risk Level (RL)	Note
Introduction of the concept of predicted resources allocated to transport infrastructure; stability of expenditure at the state level - long-term perspective	state	5	4	20	Concept of cyclic (preventive) maintenance
Stability of allocated funds (mandated expenditure) at the level of regions and municipalities	region	5	3	15	
Under-maintained infrastructure	region; administrative organisation	5	4	20	Risk of further deferral of maintenance and associated increase in under-maintenance
Compliance with the expected timetable of individual actions	administrative organisation	3	4	12	
Occurrence of additional/supplemental work	administrative organisation	3	3	9	Matter of selection of construction contractors

Errors in the planning of construction activities	administrative organisation	4	2	8	
Staffing of the organisation's activities	administrative organisation	3	3	9	
Legislative risks	state	5	3	15	
Construction work prices (including materials)	market	4	3	12	
Energy prices (taxonomy implications)	EU	4	3	12	Change in the concept of "clean" energy; implications for allowance prices

Risk map showing the number of risks in each segment:

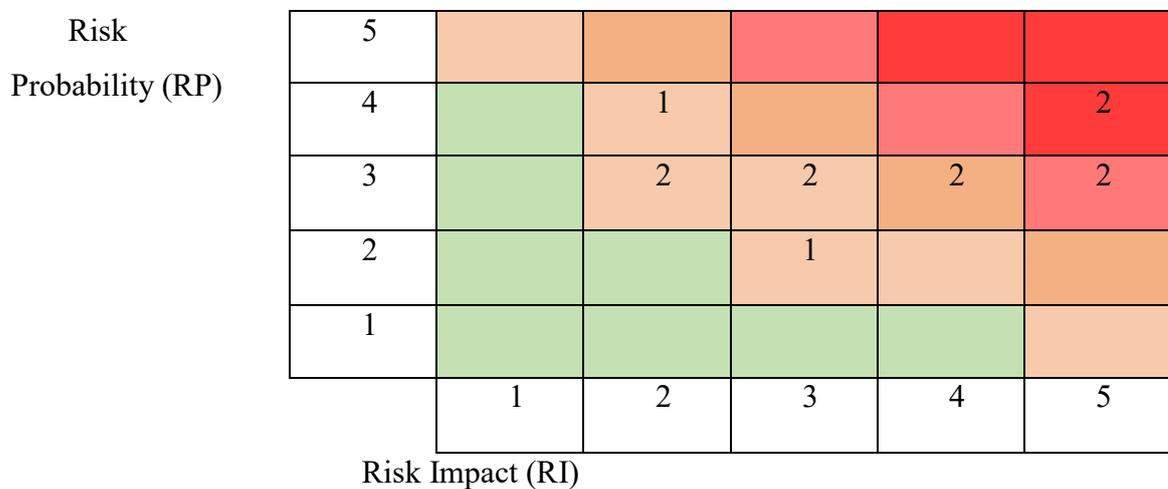


Figure 3 Risk map Source: Author

Based on a comparison of the two approaches, the following conclusions can be drawn:

- The concepts differ in the details of some risks, which can be explained, among other things, by differences in the conception of the timeframe for planning, which is also reflected in the consequences of specific actions.
- In the case of ad hoc maintenance, one risk was identified as extreme. This is the risk of further increasing the under-maintenance of the infrastructure.
- Other risks are similar in terms of frequency in the RL categories.

- The concept of cyclical maintenance has the potential to increase the level of certainty in terms of planning activities that depend primarily on the extent of available funding. Including the direct impact on improving the quality of the infrastructure for users.
- The use of a cyclical approach to maintenance also contributes to the philosophy of the circular economy.

It is necessary to mention here, that the Risk management should be seen as a continuous activity, where the above steps need to be repeated and especially deviations need to be monitored.

It is important to focus on both positive and especially negative deviations. In doing so, deviations can occur both in the probability of the risk occurring and in the level of impact.

4.1. Economic context

The complexity of comparing the concepts of cyclical maintenance and ad hoc road management is directly linked to the issue of financial resources.

In the context of the above, there are many aspects to be seen, a large number of which are in the level of uncertainty.

These include, for example, the 'correct' and above all realistic concept of the definition of the service life of a transport structure, which can be and is influenced by traffic loads, axle loads of vehicles, and the resulting randomness of the occurrence of a defect in trafficability.

To illustrate this, the situation during the construction of new motorway sections, where adjacent lower-class roads are extremely congested, degrading and requiring additional financial resources for reconstruction.

The question is whether public resources are prepared to bear the costs of the destruction of roads due to construction loads in addition to the construction of new infrastructure.

Practical experience shows that in many cases this is a complex issue where the problem must ultimately be resolved at political level.

Similarly, the demands on public resources need to be seen in the same perspective, where, with the current tight budgets, there are efforts to eliminate mandated expenditure and focus on extra-budgetary sources.

In elementary terms, this is about ensuring that costs do not weigh on the expenditure side of the budget. This is also linked to efforts to raise extra-budgetary resources.

This can be done in various ways, by using extra-budgetary resources, alternative financing, PPP, and so on.

However, it must always be borne in mind that ultimately the costs will be met from public funds, and these will be reflected in the relevant budget chapters, whether at national or municipal level.

With this in mind, it is therefore clear that in many respects this is more a case of delaying the impact on public budgets.

In any case, both options can be considered in an economic context. It is a comparison of the cut-off point where the cost of one mode of governance is bridged over to the other.

Methodologically, several possible outcomes of the inter-comparison of financing options can be expressed. These are illustrated in the Figure 1.

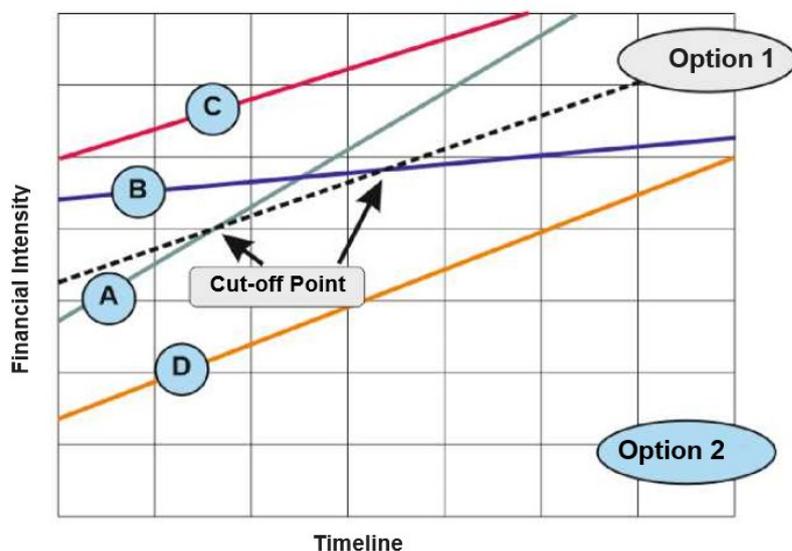


Figure 4 Possible outcomes of the inter-comparison of financing options

In a situation where the cost lines or curves intersect, it is a matter of finding the cut-off point of advantage for one or the other option.

Other situations may arise in the comparison. It is not always the case that the two lines (the line representing Option 1 with line B or A) must intersect, as shown above.

For example, if one of the options has a lower cost over the whole range (D) or, conversely, a higher cost (C), there will be no intersection over the whole range of the considered timeline (lifetime). The limiting case is the parallelism of the two lines, in which case the benefit cannot be determined.

However, it is not possible to objectively define a universally applicable mechanism for comparing financing methods. There are many factors that play a significant role.

The recent situation shows that the interest rate is one of them. In the long term, the interest rate factor is a crucial parameter in managerial and financial decisions about the implementation of the contract itself or the choice of financing method.

This is, of course, also a consideration of the concept of the road management approach. It is also necessary to bear in mind the time aspect, where infrastructure investments, even in terms of ensuring ongoing maintenance and repair, are considered over a period of years or even decades. It always depends on the particular section, its parameters, load, etc.

4.2. Case study

The basic interest rate announced by the Czech National Bank is set at 7% as of the date of the thesis. If we look at the outputs of the DOE study (source: Economic part of the study, Presentation of the CBA analysis of the construction of the Danube-Oder-Elbe Water Corridor, 2018), in which the EIRR (Economic Internal Rate of Return) criterion was set at 5%, only 2 options out of 7 met this parameter. In the case of the DOE with the Danube connection near Bratislava it was 5.2%, and in the case of the DO (Danube and Oder branches) with the Danube connection near Bratislava it was 6.1%. The options were calculated up to 2079 and an estimate of external costs was also considered. The values of the internal rate of return are therefore below even the current base interest rate.

5. Results and discussion of existing issues

Most documents on sustainability focus mainly on sustainability in building or creating new, including infrastructure, with maximum use of renewable resources and minimum impact on the environment.

In the case of infrastructure, however, the focus should be more on the sustainable maintenance of existing infrastructure and how to maintain existing assets more sustainably.

If changes are to be adopted in this area, it will not be without an increase in funding in these areas, which in effect goes against the economic pillar of sustainability.

If the road administration and maintenance are to focus on changing practices towards greater use of environmentally friendly practices in all operations related to the maintenance of the assets and buildings entrusted to it, this will logically entail an increase in financial requirements.

Sustainable maintenance is more than just not wasting non-renewable resources. The cost-effectiveness of current practices needs to be addressed and possible changes proposed to reduce costs and, ultimately, the social impact of all activities undertaken.

As can be seen from the above, sustainability in the management and maintenance of infrastructure has its own specifics that need to be implemented in sustainability documents, or the rules for meeting sustainability objectives need to be adapted to the conditions of a specific part of the national economy.

So the question is, what is sustainable maintenance anyway? Does sustainable maintenance fulfil the condition of cost-effectiveness? Is maintenance that respects the rules of sustainability more cost-effective than the practices currently in use?

The basic principle of maintenance is to look after the assets and liabilities entrusted so that they can be used repeatedly or for longer. However, this entails the use of a certain amount of material, money and energy, which can bring with it so-called externalities, i.e. unintended and dangerous by-products that can have a negative impact on the environment.

If sustainability is to be implemented in the current sustainability model and sustainable maintenance is to be introduced, the future environmental impacts of activities leading to the extension of product life cycles need to be estimated.

It is therefore necessary to select specific maintenance activities and assess their environmental impact, propose alternative, sustainable solutions and then assess the environmental impacts of the alternative solutions. This approach is likely to show that there are situations where maintenance is less sustainable than new construction or replacement of an existing element than the less sustainable artificial extension of the life cycle of that element under sustainable maintenance. This is likely to entail a need for a change in the strategic approach to sustainable maintenance.

It is therefore necessary to define and specify the basic maintenance criteria for sustainable infrastructure.

The main criteria that should be considered when assessing sustainable maintenance are:

- The age, or useful life, of existing infrastructure.
- The life cycle of individual infrastructure elements and an assessment of the effectiveness of their maintenance, and therefore the extension of the life cycle of these elements.
- Maintenance cycle and assessment of the increase in environmental impacts of maintenance with the frequency of the maintenance cycle.
- The demands of maintenance activities on financial and non-financial resources and the amount of energy to be invested in sustainability.
- The end effects of maintenance, such as the generation of pollutants, waste of different hazardous levels, etc.
- Environmental impact of machines and products used for maintenance (e.g. lubricants).

Once the individual criteria have been established, it will also be possible to determine their specific impact on the product's life cycle and sustainability and compare them with alternative solutions. Such a comparison may then lead to the identification of different alternatives and improvements.

So why is sustainable management and maintenance important? Sustainable management and maintenance can help reduce the environmental impacts of individual activities and also reduce, eliminate or recycle waste from individual activities within the circular economy.

Here, however, it would be necessary to add efficiency, or the effectiveness of the individual maintenance steps, to sustainability in management and maintenance. This could lead to an increase in the performance of the whole management and maintenance process, both in environmental, social and economic terms.

Sustainable management and maintenance of infrastructure in terms of its environmental impacts can help reduce externalities arising from its very nature. You can also help extend the life of individual infrastructure elements and associated equipment and reduce cost and consumption requirements.

There may also be economic benefits closely linked to sustainable management and maintenance, as the introduction of sustainability features can help to improve resource utilisation rates, avoid unnecessary waste and reduce the costs associated with potential penalties for exceeding established limits.

Sustainable management and maintenance are important because they allow to increase the performance and efficiency of business activities, both in terms of the environment, society and economic efficiency.

Based on the above, the following conclusions can be drawn regarding the approach to asset management in the roads sector:

The choice of funding method will always be a managerial decision at the appropriate level of public resource management. The approach to be decided here will also be whether to use the ad hoc principle or whether to apply the principle of cyclical maintenance.

For the organisation managing the infrastructure itself, this is an external factor that must also be considered from a risk perspective.

By its very nature, asset management in the road sector is a "circular" concept of asset management.

The principle of cyclical maintenance is applicable in the context of road sector management. Cyclic maintenance has its advantages and disadvantages. It is a kind of "preventive" concept, working with an estimate of the risk of a defect occurring. However, it creates requirements for a predicted allocation of financial resources. These become mandated from the point of view of budgets.

Simple economic indicators, such as the internal rate of return, cannot be seen as dogma in the long run, as evidenced by developments in the last decade.

It seems that there are four simple rules that can help to implement sustainability in management and maintenance:

- Use resources only to the extent strictly necessary
- Use resources with due diligence
- Use resources repeatedly
- Promote circular economy

Using resources only to the extent strictly necessary means that one of the first things to consider is whether the maintenance of a particular asset is necessary at all. If it is, the focus should be on how the frequency of maintenance tasks could be reduced without significantly reducing the quality of the required performance. It should be investigated whether management and maintenance tasks can be carried out more efficiently, which would help to reduce their impact on the environment and, consequently, on the frequency and intensity of future maintenance.

In case of using resources with due diligence means that sometimes there is no alternative to using scarce resources, but it is still possible to use them in an economical and sustainable way.

Using resources repeatedly is one of possibilities of road maintenance, because currently where possible, renewable or reusable resources and materials should be used.

Promoting the circular economy can be one of the ways how to get out of the crisis. So we need to find financial and other sources to support circular economy as a tool of sustainable development in road maintenance.

Sustainable maintenance is important because it enables an organisation to improve the performance of its activities in terms of the environment, society and the economy. Environmentally sustainable maintenance helps you to reduce emissions and waste. Socially it can improve worker health and safety, while economically you can improve utilisation rates and reduce costs associated with breakdowns and fines. If sustainability is to be implemented into management and maintenance, you need to consider the environmental impacts of specific maintenance activities, compare them to the impact of alternatives and change your strategy if necessary.

The above shows that it is possible to use the circular economy as a tool for sustainable development in the roads sector and this is not a new concept. The currently used ČSN standards not only allow but also prescribe the use of recycled material from demolished buildings for the construction of new buildings. If construction project promoters followed the same path and started using secondary raw materials, it would be possible to create pressure on the market for products and services that increasingly use innovative or circular solutions. With the current support of the state and the EU, the implementation of the circular economy could be achieved in a step-by-step approach.

It is generally agreed that sustainable transport should permanently contribute to increasing socio-economic well-being while not depleting natural resources and destroying the environment. The common goal is to ensure a certain quality of life that includes clean air, quiet residential areas and economic prosperity without harmful effects on health and the environment and the depletion of limited natural resources.

Sustainable transport refers to the broad field of transport that is sustainable in terms of social, environmental and climate impacts. The sustainability of transport is evaluated both from the point of view of specific means of transport, from the point of view of demands on resources and also on infrastructure. Thus, the sustainability of transport is largely measured by the efficiency and effectiveness of transport systems, as well as the environmental and climate impacts of the systems.

However, what is being addressed less, or at all, is how to sustainably maintain the transport infrastructure at the required quality.

Road management has been underfunded for a long time, and maintenance is thus carried out ad hoc (as mentioned above) instead of cyclical maintenance, which would be less demanding on non-renewable resources and therefore sustainable, but on the other hand, demanding on financial resources.

One of the possible solutions that this work aims at is the use of crisis management to change the existing maintenance system to a new, long-term sustainable system, i.e. cyclic or circular.

The aim of the work is therefore to propose a procedure for the implementation of cyclical maintenance and thus sustainability into the conditions of the Administration and maintenance of transport infrastructure.

The roads maintenance sector, like society as a whole, is going down the road of consumerism and consumption, despite the fact that the EU has set a clear sustainability path in its strategies, including transport and related services. This may be due to a certain societal setting, but also to the fact that EU strategies are often drafted very broadly, thus lacking a tool that would help to narrow down the prescribed strategy and thus make it easier to implement in a specific area. By studying the current economic management tools used in this area, the dissertation aims to provide a theoretical background on the basis of which it would be possible to create a tool that would be beneficial in this respect for companies operating in the roads sector and thus enable them to obtain the opportunity to economically evaluate those areas of sustainability that are currently not economically evaluated.

Transport is one of the cornerstones of European integration, as it is necessary to ensure the free movement of people, goods and services. At the same time, it stimulates the European economy

Based on this work, it is possible to state that there are two types of sustainability: financial and environmental.

When financial sustainability is not met, environmental sustainability cannot really exist.

An answer needs to be found on how to make road infrastructure and its maintenance in the hands of local government both financially and environmentally sustainable.

So how can asset managers and engineers have financially sustainable roads while ensuring that maintenance is both environmentally friendly and socially responsible?

Well, something must change by looking at new ways of doing things, embracing modern technology and methodologies.

Sustainability is becoming the norm nowadays and is required. However, it is necessary to create a network of support tools for the implementation of concrete steps towards sustainability also in the field of road infrastructure maintenance.

Sustainability is about interconnectedness. We cannot do without smart solutions. Finding and implementing such solutions, however, tends to require financial resources in the short term, so that they can bring non-financial benefits in the long term.

Currently, the effort to behave sustainably and responsibly in the field of road infrastructure maintenance is built more or less on the basis of charity. Sustainability is still largely linked to social responsibility activities, and this needs to change in the future. However, the change must be conceptual and supported both financially and legislatively.

Based on the analysis of the current situation, it is first necessary to identify the problematic areas that hinder the correct implementation of sustainability in the roads sector and thus to determine whether the roads sector sustainability system currently meets the conditions for sustainability, especially in terms of financing, appropriate management of financial flows, economic efficiency, organisational structure, human resources, asset protection, legislative and environmental protection and, last but not least, ethics. Finding and implementing such a tool will of course carry certain risks.

Risks generally threaten the achievement of organizational goals and have a potentially negative impact on the operations of any organization.

Risk management tries to eliminate these negative effects as much as possible. In connection with sustainable development, we talk about risk management in particular about the risk of endangering the environment and it is included in environmental management.

Risk management is a continuous, cyclically recurring set of interrelated activities, the goal of which is to manage, mitigate or completely eliminate potential risks, i.e. limit the probability of their occurrence or reduce their impact. The purpose of risk management is to prevent the escalation of critical situations.

In the case of road management, the financial level of risk related to the performance of the function of administration and maintenance of the transport infrastructure is essential for the evaluation and assessment of risk.

Risk management is not only about analysis, but about the actual management of possible risks when implementing new methodologies and procedures.

Risk rarely exists in isolation, in most cases it is various combinations of risks that ultimately create a threat to a given entity. Considering the large number of risks, it is necessary to determine priorities from the point of view of the impact and probability of occurrence of the risk and to focus on key risk areas. The risk reduction process must always begin with their analysis. Risk analysis is usually understood as a process that defines threats, the probabilities of threats and, above all, the impact on subjects. Risk analysis can therefore be understood as the determination of risks and their severity, both from the point of view of the internal environment and from the point of view of the external environment.

The term risk analysis is often used in practice as an umbrella term for identification, self-analysis and quantitative assessment. Risk assessment is often included under this term.

Risk experts agree that many organizations still do not have an effective risk management system in place. Risk management is implemented unsystematically, it does not try to detect their causes in time and resolves the situation only when something undesirable happens. Excessive confidence in established procedures and generally accepted forecasts (economic, market, financial, personnel) is common. The organization then has no choice but to correct the consequences of various unwanted events that may not have occurred at all. Every process is subject to risks and is a source of risk. Process changes are constantly occurring in every organization, which are always associated with the emergence of new risks.

For the reasons mentioned above, part of the work was devoted to risk analyzes during ad hoc and cyclical maintenance of the transport infrastructure.

The complexity of comparing the concepts of cyclical maintenance and ad hoc road management is directly linked to the issue of financial resources.

In the context of the above, there are many aspects to be seen, a large number of which are in the level of uncertainty. These include, for example, the 'correct' and above all realistic concept of the definition of the service life of a transport structure, which can be and is influenced by traffic loads, axle loads of vehicles, and the resulting randomness of the occurrence of a defect in trafficability. To illustrate this, the situation during the construction of new motorway sections, where adjacent lower-class roads are extremely congested, degrading and requiring additional financial resources for reconstruction. The question is whether public resources are prepared to bear the costs of the destruction of roads due to construction loads in addition to the construction of new infrastructure. Practical experience shows that in many cases this is a complex issue where the problem must ultimately be resolved at political level.

The aim of the thesis is to find a tool for setting up a support system for the implementation of sustainable development in roads sector and intensification of sustainability management at the level of regional roads authorities in the Czech Republic.

The results of this thesis is to give to maintenance organisations at the level of regions, their founders, the Ministry of Transport of the Czech Republic, the Ministry of the Environment of the Czech Republic and organisations established by them, such as the Road and Motorway Directorate of the Czech Republic or the State Fund for Transport Infrastructure some tool that would help to move society away from current consumerism and direct it towards compliance with the basic principles of sustainability, it will be a generally applicable tool with the possibility of developing economic theory and extending it to include the dimension of sustainability.

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