

Article

Increasing Importance of Risk Management in the Context of Solid Waste Sphere Reforming in Russian Regions

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Abstract: This article analyzes the risk factors influencing the achievement of solid waste sphere reforming goals in Russia. The given arguments present the current state of the reform as not very effective from an economic, environmental, and social perspective. The authors identify four groups of risk factors and put forward, as a critical condition for successful reform, the availability of reliable information, as well as risk management incorporated in the decision-making process. The basis for the research execution was the information from the regional solid waste sphere Master Plans and expert opinions on the readiness to achieve the reform goal regarding 100% MSW sorting based on the staff performance, public awareness, technology availability, and tariff validity assessments. The authors use a decision tree method and MSW sorting system development scenarios to provide the pessimistic and optimistic evaluation on the potential for fulfilling the reform tasks. The conclusions indicate the unattainability of the goals set by the Russian authorities for MSW sorting by 2030. The authors propose to change the status of risk factors through the implementation of certain measures for the transition from a negative to a positive scenario of reforming and to set the realistic goals for MSW sorting in Russia.

Keywords: risk; management; solid waste; reforming; region; MSW sorting; public awareness



Citation: Degtereva, Viktoria, Maria Liubarskaia, Viktoria Merkusheva, and Alexey Artemiev. 2022. Increasing Importance of Risk Management in the Context of Solid Waste Sphere Reforming in Russian Regions. *Risks* 10: 79. <https://doi.org/10.3390/risks10040079>

Academic Editor:
Tatiana Kudryavtseva

Received: 22 February 2022

Accepted: 25 March 2022

Published: 8 April 2022

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1. Introduction

Territories around the globe are facing contradictions between economic growth and environmental protection and these problems are becoming more and more obvious due to rapid industrialization and urbanization. On the one hand, the goal of the world community is sustainable development, but on the other hand, the consumption of materials and energy is increasing (Vasilenok et al. 2021). Most of the regions in the Russian Federation represent the territories challenged by the insufficient administration of waste-management systems and wasteful usage of resources. The publications of the world's leading experts on waste management provide supporting facts about the limitations for sustainable development of cities without taking into account the regenerative capacity of materials and energy. Oliveira et al. (2021) draw attention to the feasibility of renewable resources inclusion in economic circulation. Recently, the growing trend of production and consumption waste generation in the Russian regions highlights the relevance of taking into account their potential in reproduction processes. Landfill disposal of solid municipal, industrial, and construction waste is still the most common method of handling them in the Russian Federation (Nikanorova and Lebedev 2021). At the same time, most of the landfills located in the territory of Russian regions are approaching the limits of their filling capacity and

moving to the final stage of the life cycle (Muzalevsky et al. 2019). In some regions, geographical location and environmental conditions do not allow continued landfilling of huge amounts of solid waste (Nikolaev and Ipatova 2021).

All the above-mentioned causes justified the urgency of a radical change in the principles and methods of waste management in the Russian Federation and forced the beginning of the reform of the industry in all the regions of the country. The reforming process started several years ago, but so far, the reform has brought more negative results than positive ones. Among the main reasons for the failure to fulfill the tasks of the reform is the lack of a risk-management methodology incorporated into the documents administrating the waste-management sphere in Russia.

The sustainable development of the municipal solid waste (MSW)-management system, set as a priority in the strategic document “On the National Development Goals of the Russian Federation for the period up to 2030” (2020), assumes the achievement of 100% sorting and a two-fold reduction in the volume of waste landfilling. Such ambitious goals, in addition to the adoption of regulations and the introduction of new technologies, require solving the problems of risk management and improving the information support of the reform process in this area. The availability of complete and up-to-date information is necessary both for the justified adoption by authorities and enterprises of managerial decisions to improve the economic, environmental, and social efficiency of waste management, and for the active involvement of the population in this process, taking into account the introduction of separate collection.

The aim of this research is to assess the impact of various factors on the risk of failure to achieve the goals of solid waste sphere reforming in terms of sorting waste and separating the useful fractions from the waste stream. Based on expert assessments of the quality of financial, technological, informational, and staff support of the reform in the Russian regions, pessimistic and optimistic scenarios for the development of the situation are presented.

To move from a pessimistic to an optimistic scenario, it is necessary to introduce a number of measures to improve the quality of all types of factors ensuring the waste-management process. As a limitation, it should be mentioned that the study took into account only municipal solid waste, where the population of Russian regions is involved in collection and sorting.

2. Discussion

2.1. Legal Framework for Solid Waste Sphere Reforming in Russia

In modern society, a reform (from Latin *reformation*—transformation) is an integral part of the development of any social, economic, or industrial system. It usually comprises the substantial reorganization of some aspects of the system’s functioning. Formally, it could be an innovation of any content that leads to progressive changes. The ongoing reform of the waste-management system in Russia mostly covers the municipal solid waste handling process. Currently, experts estimate the total amount of MSW generation in Russia as 30 million tons a year (Tyutyukina and Tyutyukina 2020), which means about 200 kg per capita. Experts agree that the actual level of MSW recycling in the Russian regions does not exceed 15%. Hence, 85–90% of waste generated by the population goes to landfills and non-authorized dumps.

Federal Law 7-FZ “On Environmental Protection” (2002) establishes environmental requirements directly for enterprises operating waste-management infrastructure facilities, obliging them to take effective measures to protect nature, rational reproduction, and use of natural resources, improve the environment, and ensure human safety. The problem of the low level of MSW utilization is complicated by the fact that the existing landfills accepting unprocessed waste for disposal have almost reached the designed level of capacity, and there are not enough free territories around the settlements (places of population concentration) to accommodate new landfills. If new landfills are located much further from settlements, then the tariff for waste handling will increase significantly because

of the transportation cost. The growing number of landfills also negatively affects the environment and public health. The solid waste sphere reforming process was designed to solve the emerging problems. The reform was preceded by enhancing the legislation towards advancing the economic, environmental, and social efficiency of using waste as secondary resources. The strategic goals of the reform comprise solving specific tasks regarding the provision of environmentally oriented economic growth of the industry, the introduction of environmentally efficient innovative technologies and methods for rational waste management, including through the use of waste as secondary material and energy resources (Safronov 2021).

The legislation on waste management is an important part of the Russian law, which regulates the types of economic and other activities that are potentially hazardous to the environment. Undoubtedly, production and consumption waste-management activities are potentially hazardous from an environmental point of view (Kolotyryn 2016). In this regard, the state environmental policy of the Russian Federation for the period up to 2030, approved by the President on 30 April 2012, has a number of important provisions. Solid waste handling system administrating comprises taking into account the provisions regarding the observance of the human right to a favorable environment and reliable information about its condition (Stepkin and Gaydukova 2018), thereby developing and supplementing Articles 42 and 58 of the Constitution of the Russian Federation.

According to the Decree of the President of the Russia “On the Strategy for Environmental Safety of the Russian Federation for the period up to 2025” (2017), one of the global environmental challenges currently is growth in consumption of natural resources while reducing their reserves (Ovsyannikova 2020). It leads to a struggle for access to natural resources and, among the other factors mentioned by Kravchenko et al. (2021) and Rodionov et al. (2020), has a negative impact on the national security of the Russian Federation. Most popular natural resources are non-renewable and may be depleted in the foreseeable future. Thus, it is time to pay attention to waste as a source of renewable resources. Another advantage of using waste as a secondary resource instead of sending it to landfills is the reduction of greenhouse gas emissions, which is especially relevant in the context of the global course towards a low-carbon economy (Liubarskaia 2021).

Along with different steps of the solid waste sphere reforming process, several terms were introduced to Federal Law 89-FZ “On waste of production and consumption” (1998). In 2015, the concept of regional operators was developed in the Russian Federation. Each region is supposed to choose a legal entity and endow it with the functions of coordinating activities for the collection, transportation, processing, neutralization, and disposal of MSW. Initially, the reform involved the selection of a single operator in each region, but the practice has shown that in some regions several operators were selected (Putinceva 2019). In 2019, the all-Russian environmental operator was created to fulfill the same functions at the federal level. In addition, a single tariff for MSW handling operations was introduced in each region of Russia. Between 2017 and 2019, the implementation of the extended producer responsibility mechanism in Russia established the foundations for the new financial framework for the development of a solid waste-management system.

2.2. Risk Factors Influencing the Expected Results of Solid Waste Sphere Reforming in Russia

The present-day status of the waste-management system in Russia is characterized by a high level of risk, since the system is going through reforms. One of the main environmental challenges of the Russian Federation is an increase in the volume of production and consumption waste generation with a low level of their utilization (Porfirjev 2020).

In the course of studying the current state of MSW-management systems in the Russian regions, several risk factors were identified that affect the potential for achieving the goals of the reform.

These factors can be combined into four groups, which are described below and graphically shown in Figure 1:

- Factors related to staff performance, incorporating the level of qualification of employees performing various functions for the collection, transportation, utilization, and disposal of MSW, efficiency of their mutual interactions in the course of work, and concern about accomplishing the reform tasks;
- Factors related to public awareness, including the level of people's knowledge of possible ways to be involved in the proper handling of waste, especially in MSW separate collection; understanding of the reform goals; and willingness to participate in their fulfillment;
- Factors related to technology availability, incorporating the selection of environmentally sound and economically efficient waste collection, transportation, utilization, and disposal technologies and methods of their implementation in practice, taking into account specific features of SWM systems in different regions of Russia;
- Factors related to tariff validity, comprising the feasibility justification of all kinds of expenses included in the calculation of the tariff, finding a balance between the social acceptability of tariffs and their ability to cover the costs of the current operation and development of the MSW-management system.

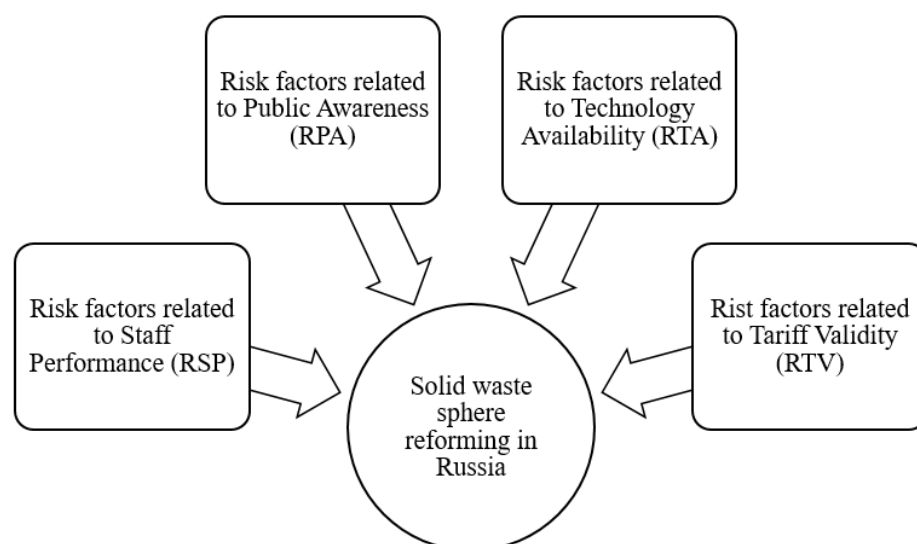


Figure 1. Groups of risk factors affecting the solid waste sphere reforming in Russia.

Since the beginning of the reform, not all the participants of the Russian waste-management system have had a clear understanding of the ongoing changes, and their interactions with each other have not always been efficient (Samoylik 2014). On the official websites of regional authorities, municipalities, and regional MSW operators, the information on the parameters of MSW-management systems is presented in fragments and not systematically. This state of affairs reduces the trust of the population both in the authorities and the performers of MSW handling functions and in solid waste sphere reform in general. This does not contribute to the dialogue and fruitful cooperation between all participants of the waste-management system (Nilitina 2019). According to Zalivansky and Samokhvalova (2021), the assertion that the Russian people have a mentality characterized by the inability to sort waste is a myth. Public opinion surveys on ongoing reforms have shown that the main problems preventing the inclusion of residents and entrepreneurs in the practice of efficient MSW handling are related to the lack of information on expected environmental and economic results of the reform.

Raising public awareness of the importance of solving environmental and economic problems of the solid waste sphere is necessary, among other things, to increase the proportion of citizens participating in MSW sorting at the household level. Unitary collection into one container of recyclables (for example, waste paper, glass, and plastic), food waste, and

hazardous substances (for example, chemicals, paints, expired drugs) significantly reduces the value and possibility of subsequent use of all listed components of the MSW stream.

Figure 2 presents the eloquent data from the research of [Zalivansky and Samokhvalova \(2021\)](#) on the attitude of the population of Russia to sorting and separate collection of MSW.

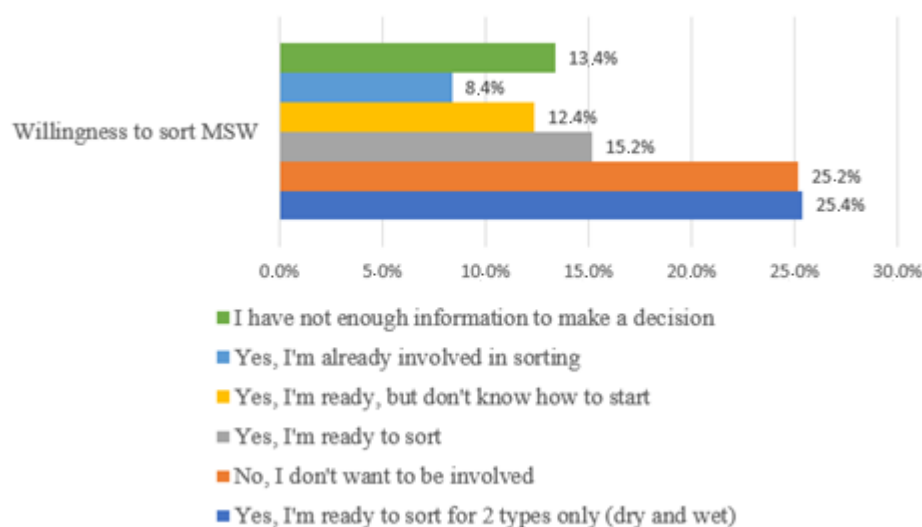


Figure 2. Attitude of Russian people towards participation in separate MSW collection.

Most of the population in Russia is ready for sorting waste at home if there are clear rules and explanations. At the moment, some people are just not aware of where the sorted waste should go and what could be manufactured from the potentially useful fractions of the MSW stream.

In some regions of Russia, the difficulties with the separate collection of MSW are caused by the improper design and location of containers. Based on the personal experience of the authors, it is worth mentioning that since the beginning of 2022, when the reform in Saint Petersburg entered an active phase, a large number of containers for separate MSW collection were taken away from container sites, and the remaining ones are constantly overflowing because of the small size. European practice confirms the importance of organizing a proper MSW collection system for improving the performance of the solid waste sphere in general ([Appolloni et al. 2021](#)). Thus, due to incorrect organizational and technological management decisions, the achievement of the goals of the reform and the decisions taken by the country's leaders on 100% sorting of MSW is jeopardized.

The haste in the implementation of solid waste sphere reform provisions into practice negatively affected their quality and led to violations in establishing the tariffs for MSW handling operations in Russian regions at an economically unjustified level. The expected response to these violations was interference in the processes by the Federal Antimonopoly Service, the prosecutor's office of the Russian Federation, as well as the residents themselves, including public organizations representing their interests ([Stepanov 2020](#)).

3. Materials and Methods

Assessment of the probability for achieving the goals of MSW sorting for particular regions of the Russian Federation is an important part of the justification of long-term projects that will be implemented in the process of reform. The level of risk for such projects is associated primarily with the uncertainty of the initial information.

According to [Safronov \(2021\)](#), any change in the waste-management system is subject to risks. The larger the scale of the system and the longer the implementation period for changes, the higher the level of various types of risks. Therefore, when reforming the waste management in the Russian regions, the risk indicator is quite high.

The existence of the risk is due to the fact that it is impossible to predict the results of solid waste sphere reforming in Russia with 100% accuracy. Based on this, it is advisable to single out the main property of risk: it occurs only in relation to the future and is inextricably linked with forecasting and planning results, and hence with managerial decision-making in general. Methods for assessing and analyzing risk in the field of solid waste management differ from methods for assessing and measuring just financial risks. When substantiating management decisions in the solid waste sphere, mostly not indirect methods are used based on a project sensitivity analysis, but direct methods are based on the use of a decision tree and future development scenarios.

The choice of a specific method for assessing and analyzing the risk of making managerial decisions depends on the information available. In this study, the authors have used the scenario method. The scenario method allows the determination of a generalized risk indicator—the expected integral risk (IR). This method is often used in evaluating the effectiveness of research projects in different countries. At its core, the method is based on the use of the mathematical apparatus of probability theory and mathematical statistics.

The scenario method overcomes the main drawback of methods based on sensitivity analysis. The fact is that it can be used to take into account the simultaneous (parallel) impact of changes in risk factors. As a result of the scenario analysis, the impact on the development indicators of the system under study is determined by a simultaneous change in all the main variables (characteristics) of management decisions. The scenario method involves forecasting options for the development of the external environment and calculating the parameters of system development for each scenario. This method is based on the study of three assumptions about possible development scenarios. The so-called most probable, pessimistic, and optimistic scenarios are developed, which allow approximate estimation of the spread of the final results of the system development.

The impact of external and internal factors can cause a change in the characteristics of the development of the system, both in a positive direction and in a negative way. An optimistic scenario takes into account the most favorable conditions, and a pessimistic one is focused on the appearance of unfavorable conditions. At the same time, these options should not go beyond a reasonably acceptable state. In our study, two scenarios were calculated—pessimistic and optimistic—and the measure for movement from the pessimistic to the optimistic scenario was suggested. Taking into account the simultaneous influence of all considered indicators, the final result will allow a conclusion to be drawn about the possible magnitude of the results obtained.

The essence of the approach used in this study is to build the scenarios based on a change in the basic variant of the results of the reform. For this, four groups of factors were distinguished; each is considered dependable and related to different aspects of MSW-management-system functioning, but the integrated influence of all the factors determines the achievement of the solid waste sphere reform goals regarding the rate of MSW sorting.

Table 1 shows data on the amount of MSW generated annually in some regions of the Russian Federation. Initially developed solid waste sphere Master Plans declared the individual goals for MSW sorting for each region of Russia. Issued in 2020, the Decree of the President “On the National Development Goals of the Russian Federation for the period up to 2030” stepped up the MWS sorting target rate by 2030 and set it up at the equal level of 100% for all the regions.

The authors, in the process of executing the research, based on consultations with experts, determined the values of the influence of four groups of risk factors on the possibility of achieving the goals of the reform in terms of MSW sorting. For the survey, a judgmental method was used to select at least 100 experts from each region, including managers of waste handling enterprises and local researchers of waste-management systems. They were asked to set an interval with the most likely level of achievement of MSW sorting goal for their region taking into account in turns the risks of improper staff performance, low public awareness, lack of necessary technological means, and tariff invalidity. Then, authors formed a pessimistic scenario (PES) from the lower bounds of the intervals by

finding a simple arithmetic mean. In the same way, the indicators of the optimistic scenario (OPT) were determined from the upper bounds. In the organizational and economic model risk assessment, methods of averaging estimates seem to be promising. In this case, the authors make the assumption that the experts have the same qualifications.

Table 1. MSW generation and goals for sorting in selected regions of the Russian Federation.

Region	MSW Generation	Goals for MSW Sorting	
	ton per Year ¹	by 2024 ²	by 2030 ³
City of Moscow	8,047,508	60%	100%
Leningrad oblast	2,960,239	80%	100%
Krasnoyarsky Krai	977,740	89%	100%
Primorsky Krai	531,568	60%	100%
Sakhalin Oblast	261,990	95%	100%

¹ In 2020, according to regional solid waste sphere Master Plan; for Leningrad oblast figure includes portion of MSW accepted from Saint Petersburg; ² according to regional solid waste sphere Master Plan; ³ according to the strategic document “On the National Development Goals of the Russian Federation for the period up to 2030” (2020).

Table 2 presents the results of the generalization of experts’ opinions regarding the readiness to achieve the goal of 100% MSW sorting based on the staff performance and public awareness assessment performed by industry experts.

Table 2. Assessment of risk factors influence on achieving the goals for MSW sorting in selected regions of the Russian Federation (Part I).

Region	Risk Factor 1 ¹		Risk Factor 2 ²	
	PES	OPT	PES	OPT
City of Moscow	53%	68%	57%	71%
Leningrad oblast	48%	63%	51%	66%
Krasnoyarsky Krai	42%	57%	45%	63%
Primorsky Krai	37%	52%	42%	61%
Sakhalin Oblast	34%	48%	39%	48%

¹ Readiness to achieve the goal based on the staff performance assessment by industry experts; ² readiness to achieve the goal based on the public awareness assessment by industry experts.

The factors of these two groups have an important impact on the achievement of the goals of the reform and are associated with the direct implementation of the adopted decisions based on the level of interest and involvement of the two most important groups of participants. These groups include the population, which, according to the initiators of the reform, should sort MSW at the household level, and employees of enterprises in the waste-management sphere, which should organize the process of collection, transportation, and utilization of separately collected waste. It will also allow achievement of another reform goal, related to the first, of a two-fold reduction in the volume of waste landfilling.

Table 3 presents the results of the generalization of experts’ opinions regarding the readiness to achieve the goal of 100% MSW sorting based on the technology availability and tariff validity assessment for the selected Russian regions.

The experts were asked to evaluate not only the present value of each risk factor in their region but also the significance of this factor in the determination of the integral risk. Figure 3 shows the equation for calculating the integral risk of failure to achieve the goals of the reform in terms of sorting MSW in the Russian Federation.

Table 3. Assessment of risk factors influence on achieving the goals for MSW sorting in selected regions of the Russian Federation (Part II).

Region	Risk Factor 3 ¹		Risk Factor 4 ²	
	PES	OPT	PES	OPT
City of Moscow	46%	57%	52%	66%
Leningrad oblast	37%	52%	46%	59%
Krasnoyarsky Krai	31%	42%	43%	54%
Primorsky Krai	28%	35%	44%	51%
Sakhalin Oblast	19%	28%	41%	52%

¹ Readiness to achieve the goal based on the technology availability assessment by industry experts; ² readiness to achieve the goal based on the tariff validity assessment by industry experts.

**Figure 3.** Method of calculation of integrated risk factor influence.

The equation in Figure 3 uses the following conventions:

RSP—industry experts' assessment of the value of the risk factor related to the staff performance influence of achieving the solid waste sphere reform goal on MSW sorting;

$K_1 = 0.27$ —industry experts' assessment of the significance of RSP factor in the determination of the integral risk;

RPA—industry experts' assessment of the value of the risk factor related to the public awareness influence of achieving the solid waste sphere reform goal on MSW sorting;

$K_2 = 0.23$ —industry experts' assessment of the significance of RPA factor in the determination of the integral risk;

RTA—industry experts' assessment of the value of the risk factor related to the technology availability influence of achieving the solid waste sphere reform goal on MSW sorting;

$K_3 = 0.29$ —industry experts' assessment of the significance of RTA factor in the determination of the integral risk;

RTV—industry experts' assessment of the value of the risk factor related to the tariff validity influence of achieving the solid waste sphere reform goal on MSW sorting;

$K_4 = 0.21$ —industry experts' assessment of the significance of RTV factor in the determination of the integral risk.

The values of the coefficients K_1 , K_2 , K_3 , and K_4 are determined by the authors based on the results of a survey of the same group of experts using the method of averaging estimates.

4. Results

4.1. Justification of Risk Management Importance for Successful Solid Waste Sphere Reforming in Russian Regions

According to guidelines provided by [ISO 31000 \(2018\)](#), incorporation of risk-management methodology into administration systems at all levels helps to anticipate, detect, acknowledge, and respond to big changes and events in an appropriate and timely manner. The importance of incorporating risk-management elements in the reforming of the waste-management sphere is determined, on the one hand, by the need to ensure the environmental safety of Russia, and on the other hand by the desire to increase the share of waste in economic circulation ([Tatarenko et al. 2020](#)).

According to this standard, risk management is an iterative process and assists in setting strategy, achieving goals, and making informed decisions, which must be achieved in order to successfully meet the goals of 100% of MSW sorting in the course of the reform. Relevant for this reform is taking into account the principles of risk management, including:

- Consideration of behavioral and cultural factors related to population, potentially involved in separate MSW collection;
- Involvement of all the participants of waste-management systems in the decision-making process;
- Continuous improvement of waste-management infrastructure in order to make it more convenient for people and businesses involved in MSW handling;
- Use of the best available information and technologies for organizing MSW collection, transportation, utilization, and disposal;
- Integration of all the above-mentioned stages and elements of the MSW handling process into the coordinated system;
- Adaptation of the results of benchmarking of waste-management systems to the specifics of local MSW streams;
- Dynamism in changes of waste-management systems in accordance with the changes in internal (for example, MSW characteristics) and external (for example, demand on secondary resource markets) conditions.

The Russian standard [GOST R ISO 31000 \(2019\)](#) is an adapted version of the international document [ISO 31000 \(2018\)](#) and is intended mainly for risk management at the organization's level. Nevertheless, the authors provide the reasoning that it can be successfully applied at the level of the waste-management industry during its reform and integrated into managerial decisions at all the stages of MSW handling process presented in the [Figure 4](#).

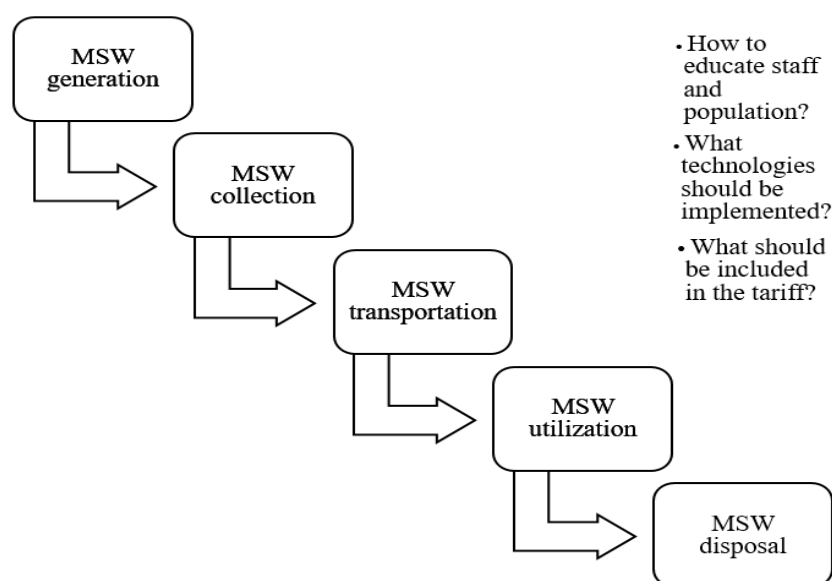


Figure 4. Stages of MSW handling process and main questions in the course of reform.

The application of risk-management methods will help to analyze all possible risk factors under the continuation of reforming the sphere of waste management and reduce their negative impact in order to achieve the goals of the reform. [Yang et al. \(2020\)](#) and [Vyas et al. \(2022\)](#) reaffirmed the links between risk analyses and MSW system performance.

4.2. Actual Directions for Improving the Solid Waste Sphere Performance in Russian Regions

An analysis of the reform process made it possible to identify several groups of factors about which it is advisable to apply risk-management methods. The first group of factors takes into account staff performance. In order to reduce the probability of failure to achieve reform goals, the following methods can be applied to this group:

- Planning of professional and personal development for staff of MSW handling enterprises;

- Coordination of interactions of the staff of MSW handling enterprises at the corporate and regional level;
- Promoting the educational and professional standards for staff of MSW handling enterprises.

The second group of risk factors is associated with public understanding of the importance of waste-management problems and achieving the goals of the reform in this area, since the population currently does not have a clear picture regarding the changes in the waste-management system under reform. To reduce the likelihood of community boycotts of participation in separate MSW collection, it is necessary to explain the essence of the ongoing changes and the possible methods of involvement of every conscientious citizen in achieving the reform goals. Diminishing the influence of this group of risk factors requires an increase in the dissemination of the information regarding reform content, especially proper methods of MSW collection and usage as a secondary resource in economic circulations. As noted in a number of studies, the involvement of educational institutions in the process of raising public awareness has broad prospects in the conditions of modern Russia (Rodionov and Velichenkova 2020; Zhurakovskaya et al. 2020; Koroleva and Kuratova 2020).

Choosing the right technology is also important (Tshovrebov and Niyazgulov 2021), so the study focused on the third group of risk factors. If the equipment and technologies for waste collection and transportation at sorting and disposal facilities do not meet the criteria of convenience for the participants in the waste-management system and do not comply with the principles of BAT, this can significantly reduce the effectiveness of the reform process. The influence of this factor can be limited by developing and implementing procedures for selecting technological organizational solutions, taking into account the 3A principle (applicability, accessibility, and affordability) for each particular region.

Finally, yet importantly, there is a mechanism for setting tariffs for waste-management services. The tariff should take into account the cost of all necessary operations for separate MSW collection and appropriate transportation to the facilities for sorting and disposal. In addition, an uncontrolled increase in tariffs should not be allowed, since this contradicts the current Russian legislation on the regulation of life-supporting infrastructure sectors. Moreover, the population will simply stop paying for waste-management services if the tariffs continue to grow, while the quality of services remains at the same level. Reducing the risk of incorrect calculation of tariffs is achieved through the use of a scientifically based approach to their determination and the establishment of socially justified restrictions on their growth.

Table 4 summarizes the results of forecasting by authors the amounts of MSW sorting in the selected regions of Russia using the scenario method based on experts' opinion regarding the readiness to achieve the reform goals taking into account different aspects of the MSW-management system functioning.

Table 4. Results of forecasting the amounts of MSW sorting in the selected regions of Russia.

Region	MSW Sorting, PES ¹	MSW Sorting, OPT ²
	by 2030	by 2030
City of Moscow	4,463,228	5,167,949
Leningrad oblast	1,472,763	1,705,305
Krasnoyarsky Krai	432,428	500,706
Primorsky Krai	216,994	251,256
Sakhalin Oblast	93,720	108,518

¹ In tons per year, based on the pessimistic estimation of all the risk factors; ² in tons per year, based on the optimistic estimation of all the risk factors.

The proposed approach and the results obtained can serve as the basis for making management decisions on the development and implementation of measures that contribute to the transition from a pessimistic to an optimistic scenario for achieving the goals of reforming in the field of waste management.

5. Conclusions

Solid waste sphere reforming in Russia was a logical stage in the direction of sustainable development of the existing system due to its environmental and economic problems. These problems have arisen in the system functioning as a whole, and the performance of enterprises involved in MSW collection, transportation, utilization, and disposal. The low level of public awareness also contributed to the deterioration of the environmental and economic performance of the waste-management sector.

Through reform, the authorities attempted to improve the efficiency of waste management and increase the share of waste involved in economic circulation. For this purpose, legislative acts have been adopted that set the tasks for the waste-management sector to organize 100% sorting of MSW. Taking into account the initial low level of separate collection and sorting of MSW in the Russian regions, the experts have serious doubts about the feasibility of the tasks set. However, discussions about the impossibility of achieving the goals have so far been carried out at the basic verbal level. According to the authors of this study, building a model that considers specific risk factors for not achieving 100% MSW sorting goals, as one of the targets for reforming the waste-management sector, allows more accurate forecasts of the development of the situation.

The hypothesis of the study is that the state-of-art of staff performance, public awareness, technological means, and tariff for MSW handling services hinders the achievement of the official MSW sorting goals. In the course of the study, the authors identified the risk factors based on an analysis of theoretical sources, and then determined the degree of their influence on the potential level of MSW sorting in five regions of Russia based on the experts' opinions. The study highlighted four groups of main risk factors, and the integral risk was defined as the sum of the multiplications of the expert assessment of the predictive level of achievement of each of the factors by its weight coefficient. The calculations performed showed that it is not possible to achieve the goals of the reform on the organization of 100% MSW sorting by the stated deadline. Limitations of the results obtained include that the study was conducted for only 5 regions out of 85.

Based on the results obtained, the authors concluded that the adoption of managerial decisions in the further course of solid waste sphere reforming should be aimed at solving two problems. On the one hand, to change the status of risk factors through the implementation of the measures proposed by the authors of the study for the transition from a negative to a positive scenario. On the other hand, it is recommended to set more realistic and specially justified goals for sorting MSW in each region of Russia.

Author Contributions: Conceptualization, V.D. and M.L.; data curation, A.A.; formal analysis, V.M.; funding acquisition, V.D.; investigation, A.A.; methodology, M.L.; project administration, M.L.; resources, V.D. and M.L.; software, V.M.; supervision, V.D.; validation, A.A.; visualization, V.M.; writing—original draft, M.L.; writing—review and editing, V.D. All authors have read and agreed to the published version of the manuscript.

Funding: The research is partially funded by the Ministry of Science and Higher Education of the Russian Federation under the strategic academic leadership program 'Priority 2030' (Agreement 075-15-2021-1333 dated 30 September 2021).

Informed Consent Statement: Not applicable.

Data Availability Statement: Data supporting reported results can be found at the following resources. Territorial Waste Management Master Plan of Krasnoyarsky Krai (Internet). 2019 (cited 24 January 2022). Available from: mpr.krskstate.ru/dat/File/3/TCOO%20Krasnoyarskii%20krai.pdf. Territorial Waste Management Master Plan of Leningrad Oblast (Internet). 2021 (cited 24 January 2022). Available from: <http://waste.lenobl.ru/ru/deiatelnost/tershema/>. Territorial Waste Management Master Plan of the city of Moscow (Internet). 2019 (cited 24 January 2022). Available from: http://www.mos.ru/upload/documents/files/1934/1_Proektdokumenty.pdf. Territorial Waste Management Master Plan of Sakhalin Oblast (Internet). 2016 (cited 24 January 2022). Available from: http://sakhalin.gov.ru/fileadmin/Scheme/TSOO_SO.pdf. Territorial Waste Manage-

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Conflicts of Interest: The authors declare no conflict of interest.

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