Evaluation of Risks to Russian Food Supply Chains during the COVID-19

Marina Ivanova[1,*]

[1] School of Business, Nanjing University of Information Science and Technology, Nanjing, China

*Corresponding author: marinaivanova020399@gmail.com

Abstract: The COVID-19 pandemic has demonstrated the vulnerability of global supply chains - the failure of one link in the supply chain can lead to numerous supply disruptions. The current study examines the main supply chain problems associated with the spread of the coronavirus and their ranking based on the perceived importance among the Russian shop owners. The study found the key factors of risks and uncertainty that might have disrupted the food supply chains in Russia during the COVID-19 pandemic and are source of food insecurity if not managed properly. These factors were identified through the literature, and later, based on the primary data collected from the grocery and catering shop owners in Russia, they were ranked using the Grey Relational Analysis model. The study found that traceability and logistical issues are perceived to be the most critical factors that have disrupted the food supply chain in the country.

Keywords: Food security; supply chain; COVID-19; Russian food retailers; grey relational analysis

1. Introduction

The COVID-19 crisis has impacted supply chain systems around the world. A necessary function is to ensure the secure movement of food products in the supply chain. This is considered desirable to support consumer confidence in food safety, particularly during a pandemic. Food security is a public health priority, although the coronavirus is not spread through food. But this has had a significant impact on food security. Although in Russia, the impact of the pandemic on the food supply chain was not so critical, the pandemic has again drawn people's attention to issues related to food safety.

The actual food supply chains were hit hardest during the pandemic. According to expert estimates, losses the Russian transportation sector incurred at the beginning of May 2020 amounted to 230 billion rubles, most of which fell on the aviation segment, which practically stopped logistics operations (Kuleshova & Kuskov, 2020). Along with this, storage facilities for food and drinks were also damaged. Likewise, rising labor costs due to labor shortages put upward pressure on operating costs. Given the duration of the pandemic, personnel management is of the utmost importance in areas that will require additional work from the outbreak onset to several weeks when contractors can make a significant contribution. The scale of the outbreak may also vary, and so far, the infection has been localized with some degree of global impact (Luckstead *et al.*, 2021). The pandemic has provided an opportunity for the people to make such changes to our food

systems so that the future disruptions can be avoided. Now consumers have become very serious about food safety and the technology that provides it.

The globalization of supply chains has greatly complicated food systems and created information asymmetries between food producers and consumers. As a result, there is a growing need for greater transparency of food origin, cultivation, collection and production methods, and working and impact on the environment (Kulikova & Suvorova, 2021). The structure of incomes of the subjects of the world agri-food market is characterized by the share participation of its individual participants in the chain in the formation of the aggregate volume of proceeds from the main types of agricultural products consumed by the population. Specific weights differ by sales channels, number, and subject composition of participants in the food supply chain in the agri-food market (Kuleshova & Kuskov, 2020). The conducted studies made it possible to detect discrepancies in the profitability of market elements in the context of implementing the functional task of providing information on volumes and nomenclature. Subject to the freedom to choose the channel for the sale of agricultural products, their quality, and delivery time, taking into account market conditions. Therefore, the current study argues that what are the key factors influencing the food security in Russian during the pandemic? How different factors differ from each other interms of their impact on the food supply chain as per the shopkeepers, who are an integral bridge between the food consumers and producers.

The rest of the article is organized as follows: the next section is devoted to a brief overview of the relevant research. Section 3 talks about the method of collecting information and processing it. Section 4 discusses the data and results. Finally, Section 5 concludes the study.

2. Background

Due to the impact of COVID-19, the global logistics system is faced with a crisis, the scale of which is a threat to the entire Russian economy. Improved border inspections and customs procedures increased delays, reduced delivery performance, and created severe logistics challenges (Verbitskaya, 2021). With globalization and the complexity of the supply chain, food hygiene risks are on the rise, and with infectious diseases and health hazards from food occurring all over the world today, food safety is becoming one of the major sustainability challenges the world must address (Kopteva *et al.*, 2020). In the food chain, at least in the short term, the main challenges relate more to supply and logistics than production. Due to the uncertainty in this process, countries prioritize the sustainability of their food systems and impose significant restrictions on agricultural and food exports. Cross-border restrictions at the country and/or city level also pose logistical problems. While food logistics is given flexibility, delays caused by restrictions can lead to food degradation, waste, and higher prices (Voronetsky, 2021). Ensuring food security is not aimed at the productive activities of organizations and agro-industrial complexes but primarily at increasing the level of vital life sustenance of the population and raising the level of the general welfare of the Russian economy. Thus, food security is considered one of the essential links in the national security system of Russia.

The COVID-19 pandemic has changed the ways and methods for monitoring food safety, now, inspections are carried out remotely, so companies need to find ways to improve technological resources for food auditing (Rejeb *et al.*, 2020). Post-pandemic travel restrictions and isolation procedures have limited the ability of food certification bodies to conduct on-site regulatory audits and issue certifications to participants in the food supply chain. Food inspectors are responsible for regulating and identifying contamination that can lead to food loss, high prices, and food insecurity. If appropriate food management processes are not developed, all supply chain stages may suffer as a result. And in connection with the pandemic, many companies were forced to switch to remote auditing, but it was also found that many grocery stores and restaurant owners do not believe that remote auditing can fully verify the quality of food products.

In the current situation, it is difficult to maintain routine activities without interruption, such as inspection of food business operations, export certification, control of food imports, monitoring and supervision of the safety of the food supply chain, etc. Traceability will help improve control

of the food supply chain to ensure the quality, taste, and safety of all products sold (Kulikova & Suvorova, 2021). Monitoring every step of the food chain is essential for grocery shops and catering to achieve these goals. One way to ensure that inventory is poorly tracked in stores and warehouses and that food is not wasted is to track current inventory throughout the supply chain. **Guided by the literature review, some challenges and issues faced by the food supply chain during COVID-19 are listed in Table 1.**

3. Research methodology

3.1 Data collection

Several owners of the grocery stores and catering businesses in the Republic of Sakha (Yakutia), Kobyaysky District, Russia, were approached. From all those who expressed interest, forty-four of actively participating in the survey. Most of the respondents were female (52.3%) and rest (47.7%) were males. Most of the respondents were grocery store owners (61.4%) and rest were the public catering owners (38.6%). Most of the respondents were adults of age ranging from 40 to 49. Most of them (52.3%) were in the business for 4 to 6 years. A link to an online questionnaire in the Russian language was sent to them electronically with a request to fill it. The questionnaire had two parts, the first one contained four demographic questions, and the second involved seven core questions. The core questions were built from the factors reported in Table 1. The core questions were like this: "Do you think the increase in customs clearance time during the pandemic affects

Table 1. Challenges and issues being faced by food supply chain during COVID-19

Code	Challenges	Description	Reference
F1	International customs clearance issues	*The pandemic has had a major impact on the work of customs authorities and has generally changed the conditions for international customs cooperation. *Parties to foreign economic activity should develop special conditions, namely clauses on the risks of a pandemic spread	Verbitskaya (2021)
F2	Transportation and logistical issues	*There are difficulties such as increased transport costs caused by changes in lead times, extended shipment times and additional prevention and control measures. *Participants in the food supply chain are forced to comply with regulations to prevent C19 contamination and incur additional transportation costs.	Kuleshova and Kuskov (2020)
F3	New requirements for food suppliers	*Daily disinfection of vehicles before entering the "clean area", regular testing of drivers for COVID, full equipment of staff. *A separate checklist was also developed aimed at monitoring control points for the prevention of coronavirus COVID-19.	Kopteva et al. (2020)
F4	Visibility and traceability	*Currently, there is no company that could independently organize a completely transparent supply chain. This requires the establishment of cooperation between partners using common standards and databases, thereby accelerating capacity development, smoothing out uncertainty in decision-making in joint work	Kulikova and Suvorova (2021)
F5	Food audits	*Post-pandemic travel restrictions and isolation procedures have limited the ability of food certification bodies to conduct on-site regulatory audits and issue certifications to participants in the food supply chain.	Rejeb et al. (2020)
F6	Air transportation	*Violation of air transportation affects perishable expensive products, primarily fruits and vegetables.	Voronetsky (2021)
F7	Post-crisis trends	*Redistribution of companies in the transport market. *Developed provision of consolidated cargo services. *Development of transport services focused on domestic transport. *Redistribution of freight traffic to rail transport. *Application of new transport technologies in the provision of transport services.	Kuleshova and Kuskov (2020)

food safety in the supply chain?". Data was collected on 7-point Likert scale, where 7 = strongly agree and 1 = strongly disagree. The complete questionnaire can be obtained from the author at a reasonable request. Table 2 presents the demographic information of survey participants.

3.2 Grey Relational Analysis

Grey System Theory was proposed in 1982 by the Chinese scientist Deng Julong (Deng, 1982; 1989). The theory is particularly useful to handle problems containing partially known and partially unknown information, small samples, and when data does not follow any particular distribution (Javed & Cudjoe, 2022; Javed *et al.*, 2020). Grey Forecasting (Tian *et al.*, 2021; Laksito & Yudiarta, 2021), Grey Numbers (Shajedul, 2021; Mahmoudi *et al.*, 2021), and Grey Relational Analysis (GRA) form the core of Grey System Theory. Angela and Angelina (2021) used the GRA to evaluate the hospitality sector's supplier selection criteria. Fahim *et al.* (2021) used the GRA to evaluate barriers affecting university enrollment. Mahmoudi *et al.* (2020) and Sheikh *et al.* (2021) used the GRA in project management. Abifarin *et al.* (2021), Obara *et al.* (2021), and Abifarin (2021) used the Taguchi-based GRA for the engineering optimizations. Peng *et al.* (2021) used the GRA to rank China's healthcare resource factors. Rao *et al.* (2021a) used the GRA for the assessment of energy poverty. Shahzad *et al.* (2020) used the GRA to find the relationships of environmental sustainability to green innovation, and corporate social responsibility. Thio (2021) used a GRA-based approach for site selection in Indonesia. Ikram *et al.* (2020) used the GRA for the assessment of the CO_2 emissions in the selected countries. Irfan *et al.* (2021) used the GRA to analyze the relationship between temperature and COVID-19 transmissibility in Pakistan. Han *et al.* (2019) applied the GRA to build a risk assessment model for quality and safety in the food industry. Grey Relational Analysis is a model for quantifying related factors that affect a target sequence.

Let the ideal sequence is $y_0 = (y_0(1), y_0(2), \ldots, y_0(n))$, and the reference sequence is $y_i = (y_i(1), y_i(2), \ldots, y_i(n))$, $i = 1, 2, \ldots m$, where in the current study $m = 7$, the total number of risks identified through the literature. The grey relational grade (GRG) is the average of the grey relational coefficients (GRC) and is given by (Mahmoudi *et al.*, 2020):

$$GRG_{0i} = \frac{1}{n} \sum_{k=1}^{n} GRC_{0i}(k) \tag{1}$$

where,

$$GRC_{0i}(k) = \frac{min_0 min_i |y_0(k) - y_i(k)| + \xi max_0 max_i |y_0(k) - y_i(k)|}{|y_0(k) - y_i(k)| + \xi max_0 max_i |y_0(k) - y_i(k)|} \tag{2}$$

Table 2. The demographic profile of the respondents (N = 44).

		No.	**%**
Gender	Female	23	52.3
	Male	21	47.7
Age	20-29	2	4.5
	30-39	5	11.4
	40-49	31	70.5
	>50	6	13.6
Work experience	<1 year	3	6.8
	1-3 years	8	18.2
	4-6 years	23	52.3
	6 above	10	22.7
Industry	Grocery shop	27	61.4
	Public catering	17	38.6

In the current study, $\xi = 0.5$. Later, the risk factors can be ranked in an order based on the value of GRG, whereas a higher value of GRG implies a more important risk factor, and a lower value of GRG indicates a less important risk factor.

4. Results

This study's practical significance is identifying the main factors affecting food safety in the supply chain, followed by its grey relational evaluation. Thanks to the data obtained during the survey, it can be concluded that COVID-19 made its own changes and affected the supply chain only because the world was not ready for such a radical change. The main conclusions that can be reached during the study of this topic and the results are that the impact of COVID-19 has led to a change in the supply chain and new high-risk trends. And the importance of this study is that food safety is a public health priority. In addition, efficient transportation reduces or prevents wasted time and materials by helping supply chain participants get their products to the right place on time. Delayed shipment can affect the next stages of the supply chain, cause food waste, increase costs and damage the company's reputation. COVID-19 has mainly caused delays in the supply chain, and delays in shipment and handling of products can affect the supply chain, cause food waste, increase costs and damage a company's reputation.

Table 3 and Figure 1 show the results. Many respondents noted that the increase in customs clearance times during the pandemic and the increase in delivery times led to additional transportation costs (F1; F2; F7). It was also found by a majority vote that new requirements for suppliers (daily disinfection of vehicles and regular testing of drivers for COVID-19) may well affect food safety (F3). It is true that no one company currently can organize a completely transparent supply chain. It was clear from the data collected through the questionnaire that the respondents believed that the traceability of goods had become a serious problem in the food supply chain during the COVID-19 pandemic (F4). In addition, many problems that need to be addressed by coexisting with the coronavirus, such as a shortage of truck drivers, long working hours, and the narrowing that some consumer markets are overcrowded. Drivers and other personnel who deliver to food facilities should not leave their vehicles when delivering food. Drivers must be provided with alcoholic hand sanitizer and wipes. Based on the collected data, it was found that the lack of labor can also affect food safety in the supply chain (F5). Russian air transportation suffered the most. Violation of air transportation affects expensive perishable products, primarily vegetables and fruits (F6). As a result, F2 and F5 are the most important, so you will find that most of the respondents feel that remote audits cannot fully test the quality of food. In addition, it was found that transport and logistics problems caused by the COVID-19 pandemic pose a more significant threat to the food supply chain. These are the factors that deserve special attention by the food policymakers and effective handling of them is of paramount importance for the food security in Russia. Also, if one looks at these top ranking factors one can see that these are the risks that are hard to be resolved automatically by the market forces and hence strong support from the government is necessary.

Table 3. The grey relational grades and ranks of the seven risk factors in three categories

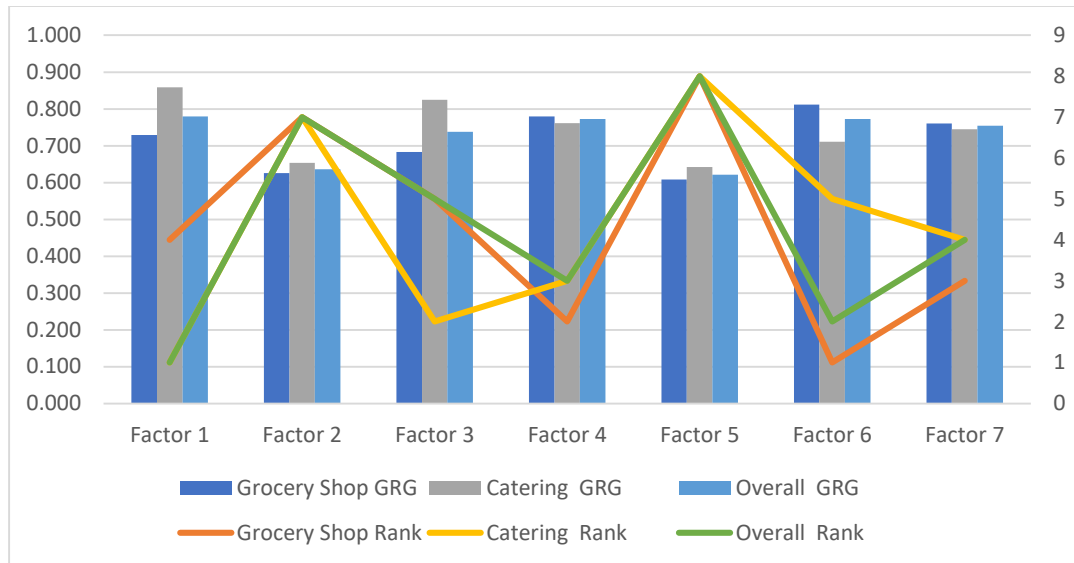| Code	Grocery Shop		Catering		Overall	
	GRG	Rank	GRG	Rank	GRG	Rank
F1	0.729	4	0.859	1	0.779	1
F2	0.625	7	0.654	7	0.636	7
F3	0.683	5	0.825	2	0.738	5
F4	0.780	2	0.761	3	0.773	3
F5	0.608	8	0.643	8	0.622	8
F6	0.812	1	0.711	5	0.773	2
F7	0.761	3	0.745	4	0.755	4

Figure 1. Grey relational grades and ranking of the factors

5. Conclusion

As companies grapple with the impact of the COVID-19 suspension around the world, governments are implementing a variety of comprehensive pandemic containment measures that further disruptions in supply, forcing companies to adapt to new conditions on the fly. Against the backdrop of the pandemic, it became obvious that to maintain business continuity, companies urgently need to maintain comprehensive strategic planning, taking into account all kinds of natural disasters, including pandemics. The food supply chain is the most basic infrastructure needed to keep it running smoothly even in times of crisis. Providing flexible sales channels from normal times can mitigate changes in consumption patterns.

Food loss and waste can reduce food market accessibility, resulting in higher prices and reduced access to low-income materials. In addition, if the food quality is inferior to the point that the food is sold at a lower price or disposed of, this could affect the well-being and livelihoods of farmers and producers. Among the challenges facing the food supply chain, especially those stemming from the COVID-19 crisis, are concerns about clustering at logistics bases such as wholesale markets. And it must be recognized that concerns about clustering in the food market are a sufficient threat. In particular, if food distribution centers such as the wholesale market are closed, the impact on a stable food supply will be enormous.

Food and food safety requirements a risk-based approach to meeting the world's food needs. Coordinated efforts to ensure food safety and reduce the socio-economic impact of a pandemic can facilitate and accelerate trade in food and agricultural products. The pandemic has provided an opportunity to improve quality, focus on the safety of employees and partners, and work regularly and well with suppliers. The past year has been a year of responses and short-term solutions. Many companies have found that their operations and supply chains are not ready to handle unpredictable peaks, and their supplier pools are not diversified enough. Manual processes in logistics also did not show the flexibility and the required speed of the result; it was difficult to make quick decisions necessary for the safety of the business, customers, and employees.

References

Abifarin, J. K. (2021). Taguchi grey relational analysis on the mechanical properties of natural hydroxyapatite: effect of sintering parameters. *The International Journal of Advanced Manufacturing Technology*, *117*(1), 49-57. https://doi.org/10.1007/s00170-021-07288-9

Abifarin, J. K., Obada, D. O., Dauda, E. T. & Oyedeji, E. O. (2021). Taguchi Grey Relational Optimization of the Multi-mechanical Characteristics of Kaolin Reinforced Hydroxyapatite: Effect of Fabrication Parameters. *International Journal of Grey Systems*, *1*(2), 20-32. https://doi.org/10.52812/ijgs.30

Angela, F., & Angelina. (2021). Grey Relational Evaluation of the Supplier Selection Criteria in the Indonesian Hospitality Industry. *International Journal of Grey Systems*, *1*(2), 42-54. https://doi.org/10.52812/ijgs.19

Deng, J. (1982). Control problems of grey systems. *Systems & Control Letters*, *1*(5), 288-294. https://doi.org/10.1016/S0167-6911(82)80025-X

Deng, J. (1982). Control problems of grey systems. *Systems & Control Letters*, *1*(5), 288-294. https://doi.org/10.1016/S0167-6911(82)80025-X

Deng, J. (1989). Introduction to grey system theory. *The Journal of Grey System*, *1*(1), 1-24.

Fahim, A., Addae, B. A., Ofosu-Adarkwa, J., Qingmei, T., & Bhatti, U. A. (2021). Industry 4.0 and Higher Education: An Evaluation of Barriers Affecting Master's in Business Administration Enrolments Using a Grey Incidence Analysis. *IEEE Access*, *9*, 76991-77008. https://doi.org/10.1109/ACCESS.2021.3082144

Han, Y., Cui, S., Geng, Z., Chu, C., Chen, K., & Wang, Y. (2019). Food quality and safety risk assessment using a novel HMM method based on GRA. *Food Control*, *105*, 180-189. https://doi.org/10.1016/j.foodcont.2019.05.039

Ikram, M., Sroufe, R., Rehman, E., Shah, S.Z.A., & Mahmoudi, A. (2019). Do Quality, Environmental, and Social (QES) Certifications Improve International Trade? A Comparative Grey Relation Analysis of Developing vs. Developed Countries. *Physica A*, *545*, 123486. https://doi.org/10.1016/j.physa.2019.123486

Irfan, M., Ikram, M., Ahmad, M. Wu, H., & Hao, Y. (2021). Does temperature matter for COVID-19 transmissibility? Evidence across Pakistani provinces. *Environmental Science and Pollution Research*, *28*, 59705–59719. https://doi.org/10.1007/s11356-021-14875-6

Javed S. A, Zhu, B., & Liu S. (2020). Forecast of Biofuel Production and Consumption in Top CO_2 Emitting Countries using a novel grey model. *Journal of Cleaner Production*, *276*, 123977. https://doi.org/10.1016/j.jclepro.2020.123997

Javed, S. A., & Cudjoe, D. (2022). A novel Grey Forecasting of Greenhouse Gas Emissions from four Industries of China and India. *Sustainable Production and Consumption*, *29*, 777-790. https://doi.org/10.1016/j.spc.2021.11.017

Kopteva, L., Romanova, I., & Lashkova, N. (2020). *Food Security of Russia: Risks And Threats*. In: European Proceedings of Social and Behavioural Sciences EpSBS (pp.353-363). http://dx.doi.org/10.15405/epsbs.2020.10.03.40

Kuleshova, E.A., & Kuskov, A.N. (2020). Vliyaniye COVID-19 na gruzoperevozki Rossii. Transportnyye trendy posle pandemii [Impact of COVID-19 on Russian cargo transportation. Transport trends after the pandemic]. *Economics and Business: Theory and Practice*, *12-2* (70), 63-66. https://doi.org/10.24411/2411-0450-2020-11073

Kulikova, O. M., & Suvorova, S. D. (2021). Designing an efficient logistics supply chain [Proyektirovaniye effektivnoy logisticheskoy tsepochki postavok]. *Regional Problems of Economic Transformation*, *4*(126), 122-129. https://doi.org/10.26726/1812-7096-2021-4-122-129

Laksito, I. Y., & Yudiarta, I. G. A. (2021). Grey Forecasting of Inbound Tourism to Bali and Financial Loses from the COVID-19. *International Journal of Grey Systems*, *1*(1), 48-57. https://doi.org/10.52812/ijgs.17

Luckstead, J., Nayga Jr, R. M., & Snell, H. A. (2021). Labor issues in the food supply chain amid the COVID-19 pandemic. *Applied Economic Perspectives and Policy*, *43*(1), 382-400. https://doi.org/10.1002/aepp.13090

Mahmoudi, A., Bagherpour, M., & Javed, S.A. (2021). Grey Earned Value Management: Theory and Applications. *IEEE Transactions on Engineering Management*, *68*(6), 1703-1721. https://doi.org/10.1109/TEM.2019.2920904

Mahmoudi, A., Javed, S. A., Liu, S., & Deng, X. (2020). Distinguishing Coefficient driven Sensitivity Analysis of GRA Model for Intelligent Decisions: Application in Project Management. *Technological and Economic Development of Economy*, *26*(3), 621-641. https://doi.org/10.3846/tede.2020.11890

Obara, C., Mwema, F. M., Keraita, J. N., Shagwira, H., & Obiko, J. O. (2021). A multi-response optimization of the multi-directional forging process for aluminium 7075 alloy using grey-based Taguchi method. *SN Applied Sciences*, *3*(6), 1-20. https://doi.org/10.1007/s42452-021-04527-2

Peng, X., Tang, X., Chen, Y., & Zhang, J. H. (2021). Ranking the healthcare resource factors for public satisfaction with health system in China—based on the grey relational analysis models. *International Journal of Environmental Research and Public Health*, *18*(3), 995. https://doi.org/10.3390/ijerph18030995

Rao, F., Tang, Y. M., Chau, K. Y., Iqbal, W., & Abbas, M. (2021). Assessment of energy poverty and key influencing factors in N11 countries. *Sustainable Production and Consumption*, *30*, 1-15. https://doi.org/10.1016/j.spc.2021.11.002

Rejeb, A., Rejeb, K., & Keogh, J. G. (2020). COVID-19 and the food chain? Impacts and future research trends. *LogForum*, *16*(4). http://dx.doi.org/10.17270/J.LOG.2020.502

Shahzad, M., Qu, Y., Javed, S.A., Zafar, A. U., & Rehman, S. U. (2020). Relation of Environment Sustainability to CSR and Green Innovation: A Case of Pakistani Manufacturing Industry. *Journal of Cleaner Production*, *253*, 119938. https://doi.org/10.1016/j.jclepro.2019.119938

Shajedul, I. (2021). Evaluation of Low-Carbon Sustainable Technologies in Agriculture Sector through Grey Ordinal Priority Approach. *International Journal of Grey Systems*, *1*(1), 5-26. https://doi.org/10.52812/ijgs.3

Sheikh, A. H. A., Quartey-Papafio, T. K., Ikram, M., & Ahmad, R. M. (2021). Critical Factors in Process Quality of Engineering Construction Projects during Building Design Phase. *International Journal of Grey Systems*, *1*(2), 55–68. https://doi.org/10.52812/ijgs.8

Thio, E. (2021). Evaluating Site Selection Criteria for Marine Cultivation in North Lombok Regency of Indonesia through GADA model. *International Journal of Grey Systems*, *1*(1), 27-37. https://doi.org/10.52812/ijgs.13

Tian, X., Wu, W., Ma, X., & Zhang, P. (2021). A new information priority accumulated grey model with hyperbolic sinusoidal term and its applications. *International Journal of Grey Systems*, *1*(2), 5-19. https://doi.org/10.52812/ijgs.27

Verbitskaya V.A. (2021). Problems of international customs cooperation in the conditions of the pandemic [Problemy mezhdunarodnogo tamozhennogo sotrudnichestva v usloviyakh pandemii]. *International Journal of Humanities and Natural Sciences*, (2-2), 107-110. https://doi.org/10.24412/2500-1000-2021-2-2-107-110

Voronetsky, D.A. (2021). Logistics trends 2020-2021: life during and after the pandemic [Logisticheskiye trendy 2020-2021 goda: zhizn' vo vremya i posle pandemii]. *Scientific Heritage*, (75-4), 23-29. https://doi.org/10.24412/9215-0365-2021-75-4-23-29