Frontiers in Applied Mathematics and Statistics

TYPE Original Research
PUBLISHED 05 June 2024
DOI 10.3389/fams.2024.1344158

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OPEN ACCESS

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RECEIVED 25 November 2023
ACCEPTED 16 May 2024
PUBLISHED 05 June 2024

CITATION
Abbasi S, Modibbo UM, Jafari Kolashlou H, Ali I and Kavousi N (2024) Environmental impact assessment with rapid impact assessment matrix method: during disaster conditions.
Front. Appl. Math. Stat. 10:1344158.
doi: 10.3389/fams.2024.1344158

Environmental impact assessment with rapid impact assessment matrix method: during disaster conditions

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In the last several decades, Iran's ecosystem has suffered due to the careless usage of natural resources. Cities have grown in an uneven and non-normative way, and poor project management has been a major issue, particularly in large cities. An even greater number of environmental factors and engineering regulations are not relevant to projects. Because of this, in order to ascertain a project's environmental impact, an environmental impact assessment (EIA), is required. Using the rapid impact assessment matrix (RIAM) is one method of applying it to EIA. Reducing subjectivity brings objectivity and transparency. During the COVID-19 pandemic, a thorough EIA was carried out for the Tehran project utilizing the RIAM and other possibilities. This research is the first to combine the methodology that was discussed during the incident. Through the use of the RIAM technique, the environmental impact of COVID-19 was to be quantified in this inquiry. The research examined lockdown procedures and the COVID-19 pandemic to create an EIA indicator. In a real-world case study conducted in Tehran, Iran, the impact of the initiative was evaluated using the RIAM methodology during the COVID-19 epidemic. The results demonstrated that COVID-19 had both beneficial and harmful effects. Decision-makers were effectively informed about the COVID-19 pandemic's environmental consequences on people and the environment, as well as how to minimize negative effects, according to the EIA technique that used RIAM. This is the first research to integrate the EIA during a crisis, such as the COVID-19 pandemic, with the RIAM approach.

KEYWORDS
environmental consequences, disaster situation, environmental management, real case study, sustainability

1 Introduction

COVID-19 impacted waste collection and organization in various ways, affecting waste segregation and recycling. The raised utilization of single-use plastics is responsible for averting the extension of COVID-19 in various sectors since the beginning of the pandemic. Waste management problems can be exacerbated by environmentally friendly alternatives to single-use plastics (1). Even though multiple initiatives are being taken to deal with the increase of MSW and SMW and to prevent infectious disease outbreaks, Movable grate burning technology, combined with a suitable disinfection process, could be a viable solution to COVID-19's waste problem. Waste management systems can be made more sustainable if disinfection methods and technological choices are chosen appropriately (2). Multiple initiatives are in progress to control the spread of infectious diseases, while also managing an increase in MSW and SMW. Waste management systems, especially those that deal with contaminated waste, can become more sustainable if disinfection methods and technology choices are made appropriately (1–9).

Using environmental impact assessments (EIAs), a project can be evaluated for its effects on different sectors and activities, and finally, solutions are offered based on the results of this assessment (10). Since 1975, major construction projects have been required to prepare an EIA report by government approvals and legislative assemblies to ensure environmental protection and sustainable development. The preparation of this report was a requirement of national laws after the completion of municipal waste landfill plans (11). Increasing amounts of municipal solid waste (MSW) are a concern for people all over the world (12). In developing countries, urbanization and improving living standards have increased the amount and complexity of MSW (13). In the absence of an EIA, a MSW disposal site can lead to severe negative environmental impacts. Environmental risks from unsanitary landfills, especially within hospitals and industries that dispose of waste, resulted in the replacement of traditional methods with environmentally sound and sustainable ones (14).

During EIA projects, the primary objective is to achieve a better knowledge of the existing landfill situation and, based on that, to present appropriate enforcement strategies for improving the environment and reducing pollution caused by landfills (15). One way to assess landfills is through a rapid impact assessment matrix (RIAM) (16). As a result of its ability to integrate all parts and parameters, this method is ideal for determining a project's environmental impacts rapidly and transparently (17). The use of RIAM is also recommended, because of its advantages. This eliminates subjectivity and facilitates transparency and objectivity. The process of operation is documented concurrently with the EIA for the project, reducing the amount of time required for the process (18). As a practical matter, RIAM provides an easy way to utilize distinguish procedures; due to each cell, a specialist will have information on the magnitude and importance of impact, and lastly, the user will be can conclude. RIAM uses a range of environmental scores (ES) to calculate the overall results that can be compared to each other. The ES is assigned to each component and is classified into ranges (19–24).

Figure 1 shows the trend chart of the creation of MSW flow. To predict the environmental consequences of any development project, an EIA is one of the proven legal and predictive tools. Impact studies employ a variety of EIA methods, but not all of them are equally effective. EIA methods and their interrelationships are most encouraging as a result of the dissemination of information. In addition to being time-consuming and costly, conventional EIAs are often subjectively biased (26). An EIA based on conventional procedures is not sufficient for comprehensively managing environmentally sensitive development projects. Consequently, GIS provides unbiased and interpretable EIAs that overcome the limitations of conventional EIAs. To evaluate road development's environmental impacts, GIS is considered the best technique. The waste flow rate in municipal waste management facilities is normally predictable and steady, with seasonal fluctuations. Medical waste volumes increased dramatically during COVID−19, while MSW volumes increased and decreased in different regions (27, 28). According to state statistics (29), MSW and organic waste generated in New York were both up 3.3 and 13.3% during the COVID−19 pandemic, respectively (9, 30–39).

Several municipal essential services were disrupted by COVID-19, including the management of municipal solid waste (MSW). By segregating waste streams and treating them separately, waste and waste management can reduce environmental, health, and social impacts (40). Depending on disposal activities, MSW and SMW have a global warming potential ranging from 0.64 to 520 (kg) carbon equivalence/tonne and 52.1–3,730 (kg) carbon equivalence/tonne, ordinary. According to Nabavi-pelesaraei et al. (41), MSW disposal costs ranged from 90 to $242/tonne, and SMW disposal costs ranged from 12 to $1,530/tonne. Impact of zinc oxide doping on the optical, surface, and structural characteristics of thin films of titanium dioxide (42). Utilizing generative adversarial networks for color correction of images (43). Image processing methods for early detection of breast cancer (44). Water usage trends and projections in southwest Ethiopia (45). Smeein et al. (46) suggested the approach of spline scaling

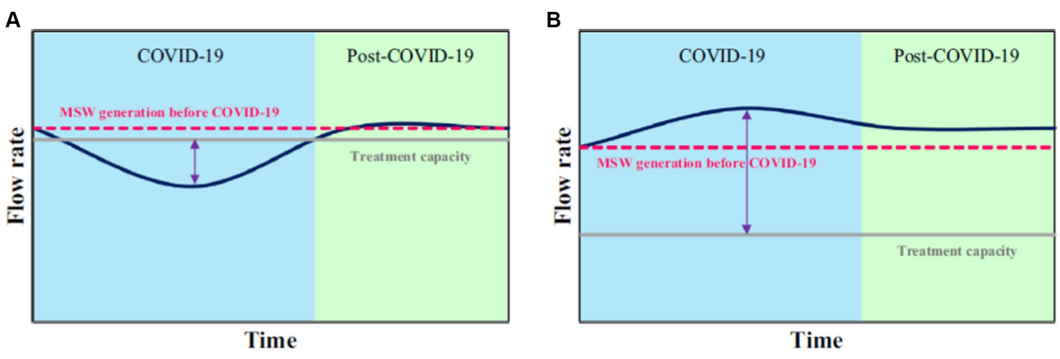

FIGURE 1
Trend chart of the creation of MSW flow rate during and after the COVID-19 period in **(A)** developed (more industrial) and **(B)** developing (less industrial) societies (city or nation) (25).

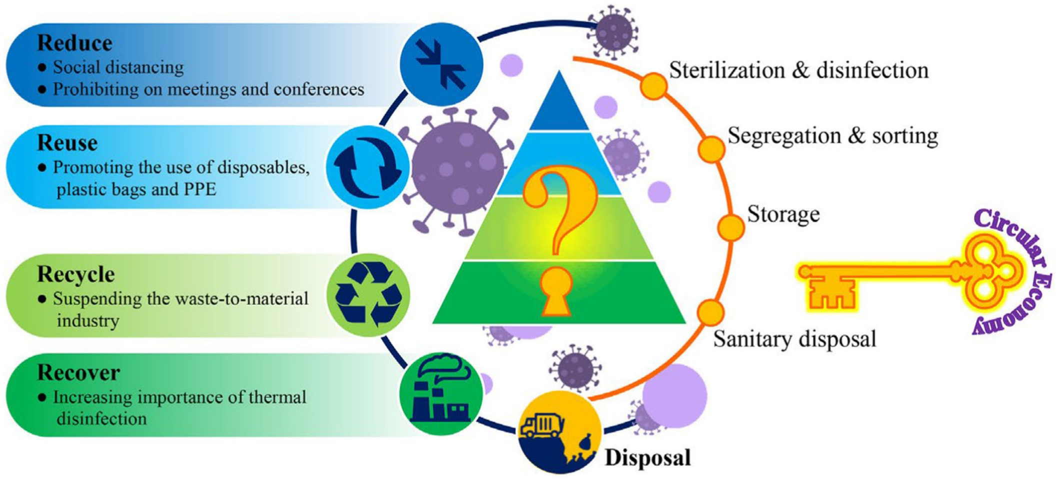

FIGURE 2
The COVID-19 waste management hierarchy (25).

functions for addressing optimum control problems has been optimized. Concentrated on the viability of using a convolutional neural network for breast cancer diagnosis by Faris and Badamasi (47). Possibility of using a convolutional neural network in mammography to identify breast cancer (48).

COVID-19/IT the digital aspect of COVID-19: An Italian image with taxonomy and grouping (49). The effect of COVID-19 on the virtual learning environment was assessed by Torres Martín et al. (50). The COVID-19 period waste management organization is depicted in Figure 2.

Uncertainty was first included in EIAs by Cardenas et al. (51). Caro-Gonzalez et al.'s review (52) on the development of EIA effectiveness. Using a case study from Colombia, Caro-Gonzalez et al. (53) examined the influence of environmental impact statement techniques. Insufficient information might lead to uncertainty difficulties, as discussed by Kamal and Burkell (54, 55). Loomis and Dziedzic (56) assessed the efficacy of EIA systems. A sophisticated network method for evaluating the effects on the environment. Martínez et al.'s impact assessment (10). For EIA, Pastakia and Jensen (57) proposed the quick impact assessment matrix approach. Resulting from EIA Forecast Uncertainty regarding post-auditing, follow-up, and mitigation (58). Predictions made by EIAs are uncertain, necessitating improved communication and more openness (59). Research on the efficacy of EIAs and the philosophical underpinnings of an integrated (60).

Catalonia and Barcelona, however, have produced less municipal waste, respectively, by 16.7 and 25.0%. Some Chinese provinces have also produced less MSW (61, 62). SMW was managed by 46 mobile waste management plants deployed by the city. Healthcare waste generation is expected to increase in Romania, with medical waste contributing 10.9 percent, and quarantine waste contributing 17.2 percent, respectively, to total waste generation. Several regions have experienced increases in agricultural waste generation because of disruptions in supply chains (SC) and processing facility closures that caused perishable foods to spoil (63). Multiple causes and effects led to the decrease in MSW during COVID-19. Takeout food and food delivered to residences have been packaged with single-use plastics following the implementation of quarantine (64). In addition to technical, economic, and environmental factors, social acceptance contributes to the process as well as the choice of disinfection technology (65). As a result of the outbreak, the current waste management (WM) systems have been swamped with waste (66). The United States reported that COVID-19 generated 530 million tonnes of waste in a given year (67). According to estimates, there will be 63,000 tonnes of plastic waste produced in Canada from personal protective equipment (PPE)related to COVID-19 (68). Tehran experienced significant air quality challenges during the excessive outbreak. Air quality could be improved by lockdowns and urban activity limitations (67). COVID-19 affected urban air quality in a variety of ways across countries, but various economic and social situations affected responses alternatively, resulting in significant environmental justice implications (6). COVID-19 resulted in residents of Tehran continuing to work despite the infrequent nationwide stay-at-home orders (69). Many developing countries have been affected by COVID-19 based on their lifestyles, the kind and quantity of waste they produce, and how they manage it. COVID-19 has been reported to have caused 14,205,416 instances confirmed worldwide and 599,716 deaths (69) in Iran, where 269,440 affirmed items have resulted in 13,791 deaths. In Iran, solid waste is often disposed of in inefficiently managed landfills where waste pickers could scavenge for recyclable materials without wearing appropriate PPE. Over 18 million metric tons of MSW are produced each year in Iran, the 18th most populous country globally (70).

During a medical emergency, Abbasi et al. (71) created the home healthcare SC. During the COVID-19 pandemic, Abbasi et al. (72) created the green closed-loop supply chain network (GCLSCN). Ahmadi et al.'s study (73) focused on power plant portfolio optimization in Iran utilizing renewable energy. To achieve sustainable development goals through financial inclusion, Danladi et al. (74) investigated cooperative methods for fintech uptake in developing nations. A stochastic bi-objective simulation optimization model for the plasma SC in the event of a COVID-19 epidemic was proposed by Shirazi et al. (75). The literature on green supply chain network design (GSCND) with an emphasis on carbon policy was evaluated by Abbasi and Choukolaei (76). A state-of-the-art evaluation of operation research models and applications for home healthcare was conducted by Goodarzian et al. (77).

Using the COVID-19 outbreak as a case study, Ghasemi et al. (78) examined the DEA-based simulation-optimization strategy for designing a resilient plasma supply chain network(SCN). Using a real-world example, Abbasi et al. (79) created a sustainable network for recovering end-of-life items during the COVID-19 pandemic. Hospital rankings in the COVID-19 epidemic utilizing a novel, integrated methodology based on patient satisfaction (80). The GCLSCNs' reaction to different carbon policies during COVID-19 was provided by Abbasi and Erdebilli (81). Pricing techniques for hotel searches conducted online: a fuzzy inference system process (82). Creating The COVID-19 pandemic's sustainable CO_2 emissions SC (83).

Using a mix of machine learning and meta-heuristic algorithms to design a sustainable bioethanol SCN (84). Evaluation of the sustainable SC's performance in light of the COVID-19 Pandemic, a case study from actual life (85). Using a case study of palm oil buying businesses, Ahmadi and Peivandizadeh (86) developed a sustainable portfolio optimization approach based on Promethean ranking. During the COVID-19 pandemic, designing a vaccine SCN with the environment in mind (87). Creating a closed-loop, multi-echelon, tri-objective, sustainable supply chain (SSC) amid COVID-19 and lockdowns (88).

The production-distribution planning issue for multi-product SCs was proposed by Khalili-Damghani and Ghasemi (89) considering fuzzy mathematical optimization methodologies. Constructing the essential item delivery network under COVID-19 and seismically unstable situations (90). In the crisis time, Gonzalez et al. (91) created a dependable aggregate production planning issue. Utilizing meta-heuristic algorithms, Goodarzian et al. (92) examined a citrus fruit supply chain network taking CO_2 emissions into account. Using the COVID-19 pandemic when designing the location–routing problem for a cold SC (93). In the COVID-19 Era, Abbasi et al. (94) examined the model for financial SCNs. COVID-19 medical waste SCN, a fuzzy sustainable model (95). An overview of the obstacles and consequences of the COVID-19 pandemic for global waste management for a sustainable future (96).

2 Literature review

2.1 Waste management during the COVID-19

During the COVID-19 pandemic, many cities in the United States and Europe banned or restricted municipal solid waste recycling centers owing to concerns regarding the spread of the infection (97, 98). It is also prohibited to separate household waste in countries, for instance, Italy, where suspected or affected individuals are isolated or cared for at home, thus reducing the amount of recyclable waste entering the waste stream. The reduced recycling of waste during the pandemic has led to environmental concerns (99). By contrast, waste pickers (informal sector) in developing countries separate waste at the disposal stage and dump it at landfills. It is very difficult and complicated to change the situation in this section. Therefore, developing countries are expected to have a greater risk of disease transmission from poor waste management (100), making garbage collection and waste management programs very important in refugee camps and slums (101).

In contrast, disease outbreaks and lockdown rules may force citizens to move from their primitive homes to secondary, which may put a strain on village WM systems, so equipment and staff capacity must be increased in these areas to improve waste management systems. Occasionally, urban waste management is impacted by pandemics (102, 103). Isfahanian citizens are discarding more than 1.49 million plastic gloves and 1.49 million facemasks, which disrupts waste composting, and landfilling increases 3.6 times compared to the period before COVID-19 (69).

According to past experiences or experiences achieved in other countries, infectious disease outbreaks caused a change in waste management. Several prior operations were stopped or resumed with notable distinctions in provisions resulting in a change in waste management (104). A behavioral change like this is essential in diminishing the likelihood of disease transmission and preventing the transfer of pollution from contaminated waste. The virus may spread to the air through compactor waste collection vehicles, for instance (105). As a result, waste management will require trucks, human resources, and more expenses. Municipal solid waste recycling will likely decrease significantly in a pandemic situation because waste recycling is the most affected part of WM. Compared to the previous epidemic, COVID-19 has seen a decrease in the waste-to-material industry (105).

Tehran has increased its landfill capacity by 35% as well (9). Since the health protocols have been implemented, the waste management system has improved (33). To limit poor waste management that leads to damage, there has to be a greater emphasis on the guidelines set out in the waste management pandemic conditions (106). Medical waste management has been significantly affected by the pandemic. To store, collect, and transport this potentially contaminated waste, separate pathways have been adopted for storing, collecting, and transporting these medical wastes (107). The pandemic has been controlled and transmission risks reduced using waste incineration, according to a report from a Chinese hospital (108).

2.2 Environmental management during the COVID-19

COVID-19 also improved Tehran's air quality indicators. Also, quieter conditions were created in Tehran due to a reduction in commercial activity and a reduction in the use of public and private transportation. As of now, Tehran is experiencing a reopening of most businesses, including restaurants. Social distancing measures are encouraged by the government, but the government enforcing them in most public places is not strict. Residents wear facemasks and follow guidelines for social distancing (109).

COVID-19 has been reduced from spreading from human to human according to guidelines issued by the WHO and other national disease control centers. Iranian National Headquarters for Managing Coronavirus (INHMC) advises the use of PPE-like facemasks for everyone. In the act of preventing or controlling the spread of COVID-19 in Iran, the Ministry of Health and Medical Education formed the INHMC. In defending against COVID-19, every governmental and private entity and sector has a responsibility to consider necessary administrative measures and collaborate with the INHMC (23, 110–112). In preventing the transmission of COVID-19,

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the INHMC recommends single-use gloves, tissues, aprons, and facemasks for medical professionals treating patients with COVID-19. Several other service employees have been praised for using facemasks and gloves, which include barbers, cooks, taxi drivers, street sweepers, and waste collectors (62, 113–117).

A new law is being proposed by the INHMC to require all residents to wear facemasks in public areas. On average, 10.78 million facemasks were disposed of every day in March 2020. People would be discouraged from using PPEs if the price of PPEs in Iran increased significantly after COVID-19 spread. In Tehran, every day 1.9 million masks and 3.8 million gloves are deleted. In particular, street sweepers and waste scavengers are at risk of becoming infected with the viral disease from the utilization of PPE. Due to changes in people's habits and the rise in plastic waste, Tehran's waste production has increased in volume and weight since the outbreak of COVID-19. During COVID-19 time, people tend to spend more time at home, which results in more waste being produced (112, 114, 118).

There has been a rise in the production and use of food waste and detergents among Tehran residents. During the pandemic, Tehran City's waste stream has seen a dramatic increase in packaging waste from detergents and disinfectants. The literature describes human COVID-19 like SARS and MERS COVID-19 have been reported to survive up to 9 days on non-living surfaces (119, 120). As a result, most people prefer single-use plastics as a safer alternative. As a result of the lockdown measures in Tehran, restaurant and grocery store delivery staff have increased their use of packaging materials. However, if discarded PPEs are not handled properly, they can aggravate health and environmental issues. A poor waste management system usually makes these environmental hazards more severe in developing countries. A typical waste collection truck in Tehran, for example, is equipped with a compactor to enable larger collections (112, 121). When COVID-19 broke out in Iran, compactors for garbage trucks were not restricted or recommended. As long as 3 months can pass before landfall leachates become contaminated (122). It may result in the spread of COVID-19 in Tehran if this strategy for collecting waste is carried out (112).

The environment may be negatively impacted by COVID-19. COVID-19 could have some positive environmental impacts due to its reduced energy consumption, according to initial reports. It has been observed that the CO_2, NO_2, and PM2.5 emissions in China have been drastically reduced as a result of the halting of the power plant and industrial activities also decreased utilization of vehicles, although such a short-term decline in emissions would not be a sustainable way for the protection of the environment since the outbreak of COVID-19 has occurred (123).

The social distancing guidelines and PPE were used by 62 and 23% of Tehran residents, respectively, during March and April. The recommended measures are currently followed by only 11% of the residents. Due to this, the only positive impact of COVID-19 on the environment has disappeared quickly, namely the reduced emissions of air pollutants (124, 125).

After the outbreak of COVID-19 in Tehran, cities are prohibited from separating and recycling urban waste for districts 6, 21, and 22 of Tehran, a pilot source separation program was launched right before the COVID-19 pandemic, where people were instructed to store their waste in three sealed containers labeled with their names. Every other day, organic waste was collected, and every other or twice a week separated recyclable wastes were collected. To encourage residents to participate in the source separation program, WMOTM paid residents according to the weight of the collected recycled waste. COVID-19 also ended this pilot program. COVID-19 has not significantly changed Tehran's waste collection procedure except for this pilot program (108, 126, 127).

It has now been declared that Tehran faces several environmental challenges related to COVID-19, like the raised utilization of particular vehicles versus public transportation, increased water utilization, and increased detergent loads in domestic wastewater. COVID-19 poses many environmental challenges in Tehran, but solid WM is particularly problematic (108). Tehran generates approximately one-fifth of all MSW in Iran, according to statistics (70).

2.3 Tehran's MSW disposal during the COVID-19

Before the outbreak of COVID-19, they were separated, composted, incinerated, or landfilled. Tehran used to bury/landfill about 4,900 tonnes of its collected waste every day (62). Additionally, around 200 tonnes of the collected waste are burnt at Aradkouh every day. Nevertheless, the Aradkouh disposal center cannot burn hazardous wastes like hospital waste because the associated disposal costs will be significantly higher, and no authorized organization is willing to take on these expenses. There is an estimated 20–30-fold increase in incineration costs for medical wastes in China in comparison to urban wastes, mainly due to the need to modify therapy and CO_2 control systems planned for the standard of quality for general waste. According to WHO guidelines, healthcare waste should be treated at temperatures between 900 and 1,200°C when incinerated in Germany (128). Additionally, the Aradkouh composting facility was able to handle 3,500 tonnes per day at its nominal capacity. Since the COVID-19 outbreak, wastes in Tehran have been buried 34.7% more often (112, 129, 130).

3 Research gaps and motivation of research

We describe innovation in the following categories and fill some literature gaps:

- This investigation aimed to measure the environmental impact of COVID-19.
- Analyzed lockdowns and COVID-19 pandemics to develop an indicator.
- During the COVID-19 pandemic, the rapid impact assessment matrix approach was utilized to measure the effect of the project.
- To evaluate the study, we used a real-life case study.
- Both negative and positive effects were shown to have been caused by COVID-19.

4 Environmental impact assessment methodology

EIAs serve primarily as a tool for informing decision-makers about the environmental impacts of a project on people and the environment, as well as to minimize adverse effects resulting from a project or a phenomenon such as COVID-19, involving engineering and other limitations.

4.1 Rapid impact assessment matrix

To gain a SRN, we need to have methods and tools to measure the environmental impact (EI). The RIAM is a useful tool for the performance of an EIA. The impacts of COVID-19 are assessed on environmental components, and for each component, a score, which is a measure of the component's expected impact, is determined. There are two groups of important evaluation criteria:

(A) Several criteria can have an impact on the final score, and that is relevant to the situation. (B) Scores should not be affected by factors that are relevant to the situation but are not capable of changing individually. There is a simple formula for determining the value assigned to each of these criteria groups. In these formulas, you can specify the weights of each component based on a defined set of criteria. To calculate the score, simply multiply the scores assigned to each of the criteria in group (A). To calculate the score of group (B), we add the scores of the value criteria. As a result, all values in group (B) are considered equally, regardless of their scores. To determine the final evaluation score (ES) for the condition, the sum of the scores of group (B) is multiplied by the result of group (A) scores.

Below is a description of the process:

$$(A1) \times (A2) = AT$$

$$(B1) \times (B2) + (B3) = bT$$

$$(AT) \times (BT) = ES$$

Where,

A1 and A2	The group's individual criteria score (A)
B1–B3	Scores for each of the individual criteria for the group (B)
A	All scores (A) are multiplied together
BT	A score is calculated by adding all (B) scores together
ES	Scoring for the condition according to the assessment

A scale ranging from negative to positive values to zero can be used to assess the positive and negative impacts of group (A) criteria. Thus, zero is an "insignificant" or "unchanged" value. In group (A), zeros are used to separate unimportant or unchanged conditions with a single measure. In group (B) criteria, zero is avoided. A zero result for all criteria in group (B) will also result in a zero score for the ES. Despite the criteria for group (A) indicating an important condition, this condition can still occur. The "unchanged/insignificant" score is "1" in group (B) criteria to prevent this.

4.2 Assessment criteria

Instead of changes associated with SC projects, criteria should be determined for both groups based on basic situations that are possibly affected. Theoretically, some criteria could be defined, but two principles must always be met: As the criterion is universal, it can be used in a variety of EIAs. Whether a condition should be treated as being in a group (A) or group (B) will depend on the significance of the criterion. Table 1 shows the criteria for assessment. In this study, five criteria were used in the RIAM. These criteria, together with their suitable judgment scores are specific.

4.2.1 Environmental components

There are four categories of environmental components, which are as follows:

Physical/Chemical (PC): Environmental aspects that are physical and chemical.
Biological/Ecological (BE): Environment's biological components.
Sociological/Cultural (SC): Environmental aspects related to humans.
Economic/Operational (EO): Impacts of environmental change on the economy.

4.2.2 Ranges

There are cells in the matrix that show which criteria were used when comparing the defined components to the criteria. Scores are set for each criterion within each cell. The formula above is used to calculate and record each ES number. For a more accurate rating system, ES values are grouped into comparable ranges (Scale) without claiming sensitivity. As a result of group (A) changes, these conditions are combined with the highest or lowest possible scores on group (B) criteria. The conditions are defined so that a range of ±5 can be created, and the boundaries of the bands in this range can be determined as follows (Table 2).

5 Case study

It was confirmed on 19 February 2020 that Iran had the first cases of COVID-19. The data for the assumed case study are used to assess the validity of the created environmental model and the functionality of the solution approach. The Company's management provided the data. The results of the model were assessed in a real-life case study. By using the data for the considered real-life case study, the precision, and functionality of the proposed model can be assessed. At last, it should be noted that the proposed model is dependable and responsive. This case study emphasizes the impact of air pollution, noise pollution, and soil and water pollution. We used COVID-19 baseline data as a basis for developing matrix alternatives for each environmental component. Figure 3 shows the situation of the real case study.

6 Environmental components during the COVID-19

6.1 Physical/chemical components

- PC1: Reducing CO_2 emissions because of decreasing recovery activities.
- PC2: Reducing CO_2 emissions because of decreasing shipping activities.
- PC3: Increasing medical waste amount.
- PC4: Increasing PPE waste.
- PC5: Reducing noise pollution.
- PC6: Bad effects of COVID-19 on WM.

TABLE 1 Criteria for assessment.

Description	Scale	Criteria
A1: The importance of condition	*4*	*Important to national/international interests*
	3	*Important to regional/national interests*
	2	*Important to areas immediately outside local condition*
	1	*Important only to the local condition*
	0	*No Importance*
A2: The magnitude of change/effect	*+3*	*Major positive benefit*
	+2	*Significant improvement in status quo*
	+1	*Improvement in status quo*
	0	*No change/status quo*
	-1	*The negative change in the status quo*
	-2	*Significant negative disbenefit or change*
	-3	*Major disbenefit or change*
B1: Permanence	*1*	*No change/not applicable*
	2	*Temporary*
	3	*Permanent*
B2: Reversibility	*1*	*No change/not applicable*
	2	*Reversible*
	3	*Irreversible*
B3: Cumulative	*1*	*No change/not applicable*
	2	*Non-cumulative/single*
	3	*Cumulative/synergistic*

TABLE 2 RIAM's range of bands.

Environmental score (ES)	Range bands (RB)	Scale	Description of range band
+72 to +108	+E	+5	Major positive change/impact
+36 to +71	+D	+4	Significant positive change/impacts
+19 to +35	+C	+3	Moderate positive change/impact
+10 to +18	+B	+2	Positive change/impact
+1 to +9	+A	+1	Slight positive change/impact
0	N	0	No change/status quo/not applicable
−1 to −9	−A	−1	Slight negative change/impact
−10 to −18	−B	−2	Negative change/impact
−19 to −35	−C	−3	Moderate negative change/impact
−36 to −71	−D	−4	Significant negative change/impact
−72 to −108	−E	−5	Major negative change/impact

6.2 Biological/ecological components

- BE1: Protection of species of flora and fauna.
- BE2: Harmful effect on human health.
- BE3: Densification of the population is reduced.

6.3 Social/cultural components

- SC1: Outcomes of the modality for healthcare, prevention, and control of COVID-19.
- SC2: There are several job openings regarding COVID-19.
- SC3: COVID-19 damages caused an average number of lost days.

6.4 Economical/operational components

- EO1: The risk of infection limits manual sorting and recycling.
- EO2: Separation costs of COVID-19 waste and from normal waste.
- EO3: Hygienic costs.

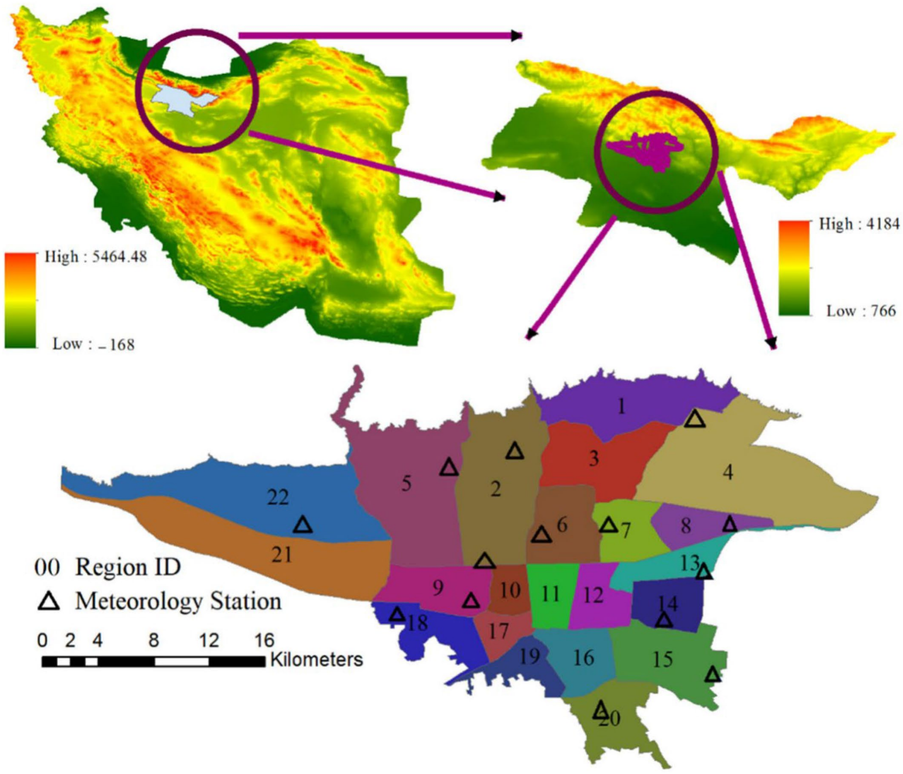


FIGURE 3
The map real case study in Iran (67).

The ES is calculated as follows:

$(AT)\times(BT)=ES$

$(\text{Importance of condition})\times(\text{Magnitude of change/effect}) = AT$

$(\text{Permanence}) + (\text{Reversibility}) + (\text{Cumulative}) = BT$

PC1: $A1\times A2 = 2\times(+2)$, $B1 + B2 + B3 = 2 + 2 + 2$, $ES = +24$

PC2: $A1\times A2 = 2\times(+1)$, $B1 + B2 + B3 = 2 + 2 + 2$, $ES = +12$

PC3: $A1\times A2 = 3\times(-1)$, $B1 + B2 + B3 = 3 + 2 + 1$, $ES = -18$

PC4: $A1\times A2 = 2\times(-1)$, $B1 + B2 + B3 = 3 + 2 + 1$, $ES = -12$

PC5: $A1\times A2 = 1\times(+2)$, $B1 + B2 + B3 = 3 + 2 + 1$, $ES = +12$

PC6: $A1\times A2 = 2\times(-1)$, $B1 + B2 + B3 = 3 + 2 + 1$, $ES = -12$

$PC1 + PC2 + PC3 + PC4 + PC5 + PC6 \geq 0$

BE1: $A1\times A2 = 2\times(+1)$, $B1 + B2 + B3 = 3 + 2 + 1$, $ES = +12$

BE2: $A1\times A2 = 4\times(-3)$, $B1 + B2 + B3 = 3 + 3 + 3$, $ES = -108$

BE3: $A1\times A2 = 4\times(+3)$, $B1 + B2 + B3 = 3 + 2 + 3$, $ES = +96$

$BE1 + BE2 + BE3 \geq 0$

SC1: $A1\times A2 = 1\times(+2)$, $B1 + B2 + B3 = 3 + 2 + 2$, $ES = +14$

SC2: $A1\times A2 = 3\times(+3)$, $B1 + B2 + B3 = 3 + 1 + 1$, $ES = +45$

SC3: $A1\times A2 = 3\times(-2)$, $B1 + B2 + B3 = 3 + 1 + 1$, $ES = -30$

$SC1 + SC2 + SC3 \geq 0$

EO1: $A1\times A2 = 4\times(+3)$, $B1 + B2 + B3 = 3 + 3 + 3$, $ES = +108$

EO2: $A1\times A2 = 3\times(-2)$, $B1 + B2 + B3 = 2 + 3 + 2$, $ES = -42$

EO3: $A1\times A2 = 3\times(-2)$, $B1 + B2 + B3 = 2 + 3 + 2$, $ES = -42$

$EO1 + EO2 + EO3 \geq 0$

Figure 4 illustrates the RIAM results for the PC components. Figure 5 shows the RIAM results for the BE components. Figure 6 shows the RIAM results for the SC components. Figure 7 depicts the total results. Figure 8 illustrates RIAM results for the EO components. Figure 9 shows the RIAM results for the four components. Although COVID-19 has damaged our environment the most important of which has been the increase in infectious, hospital, and plastic waste, in general as you see in this real case all of the ES has been positive (≥ 0), and it is shown that RN has been sustainable and greener during the pandemic and lockdown periods. So this pandemic helps the environment to reconstruct (Tables 3, 4).

7 Conclusion and future recommendation

Based on the study's findings, RIAM is an effective tool for decision-makers as it displays the results of different options and can produce transparent environmental solutions even with particularly complex scenarios. Data from different sectors can be examined within a typical matrix by common significant indicators, which provides a clear understanding of major impacts in a multi-disciplinary EIA. Assessors can rapidly record their judgments by following the discipline imposed by the matrix. Several scales are used to determine the value of a judgment, ensuring objectivity. Using a matrix with outlined components, it is possible to compare the with- and without-project conditions, compare different development options, and use "what if" scenarios when planning. Comparing alternative development strategies and options can be achieved through multiple matrices that identify the major positive and negative effects, show the interim and long-term effects, as well as display where mitigation can be implemented and reduce negative effects. It is important to note, however, that the initial step in a system

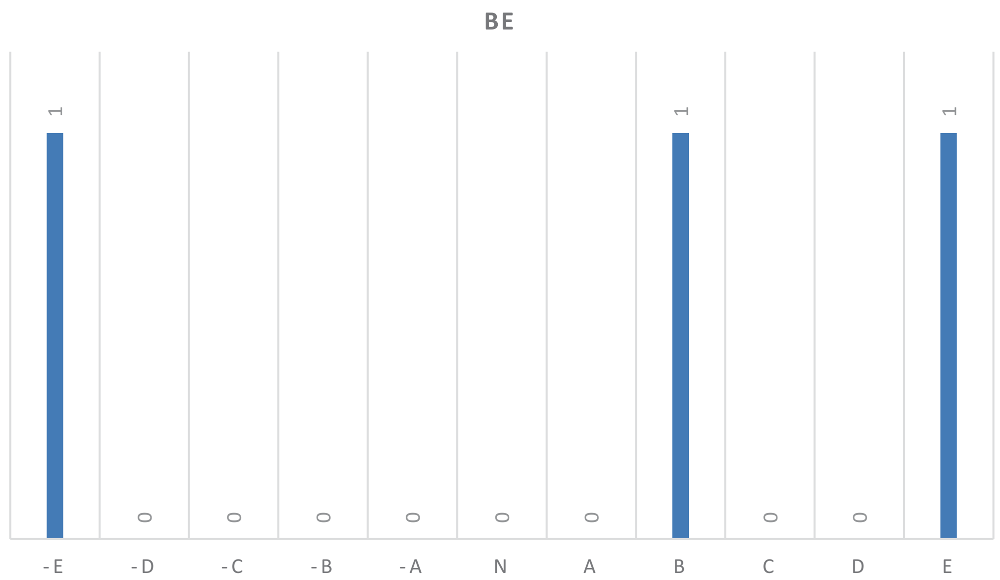


FIGURE 4
RIAM results for the PC components.

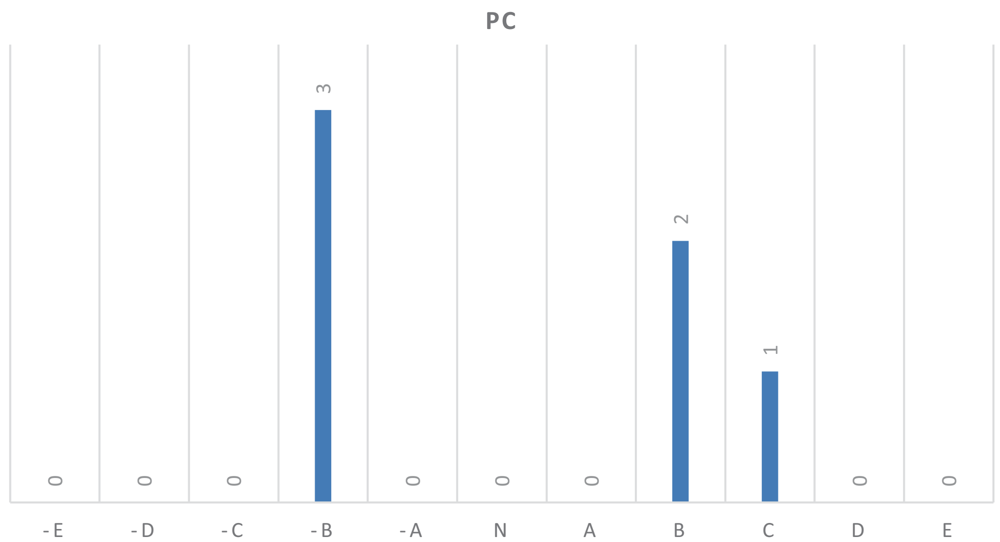


FIGURE 5
RIAM results for the BE components.

is the definition of components, and these definitions are related to the specific conditions of the project. In specific stages in a project development process, RIAM can serve as an instrument for screening and also some methodologies for detailed impact assessment. EISs can be evaluated quickly and effectively using this system of checking with defined components. The RIAM is an ideal gadget for both Initial Environmental Evaluations (IEEs) and recording the findings of a full EIA. Due to its simple nature and the ability to use the matrix even when data is scarce. In this study, RIAM was found to be a highly effective tool for applying a consistent, transparent, and easily recordable assessment of the different components of an environmental impact assessment. Furthermore, with RIAM, strategies can be compared holistically to get a better understanding of what is most appropriate for the future. Further studies on other environmental projects should be conducted during COVID-19, such as waste disposal sites in Tehran. This study was carried out from the beginning of the epidemic to its end.

In this investigation, we focused on the environmental effects according to indicators such as the emission of CO_2 and other dangerous gases, and noise pollution. It has caused ecological restoration by reducing pressure in tourism destinations, protecting plant and animal species, reducing densely populated areas, and on the other hand, increasing medical waste and disposal of protective waste and infectious waste along the project in environmental

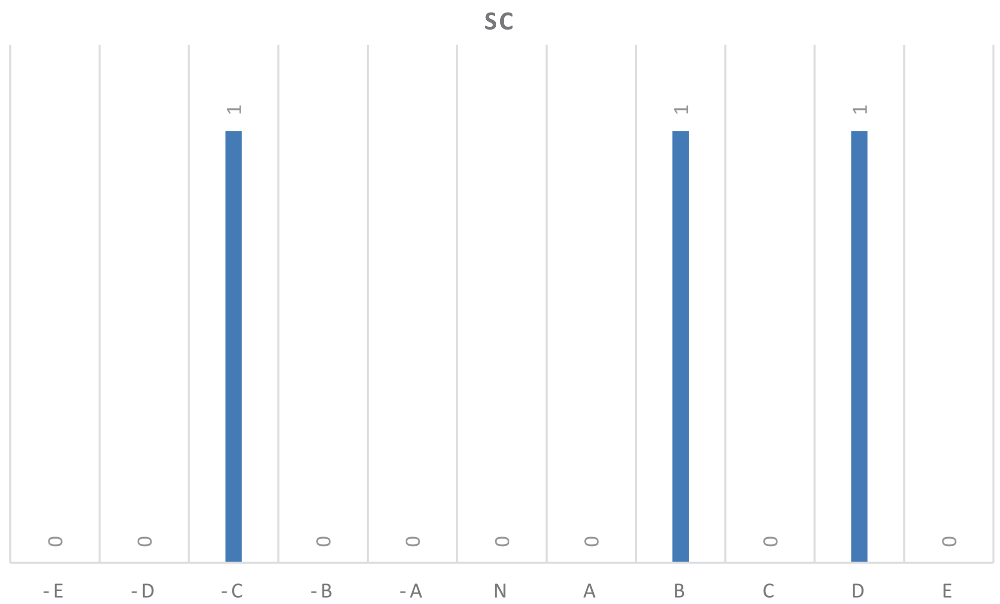


FIGURE 6
RIAM results for the SC components.

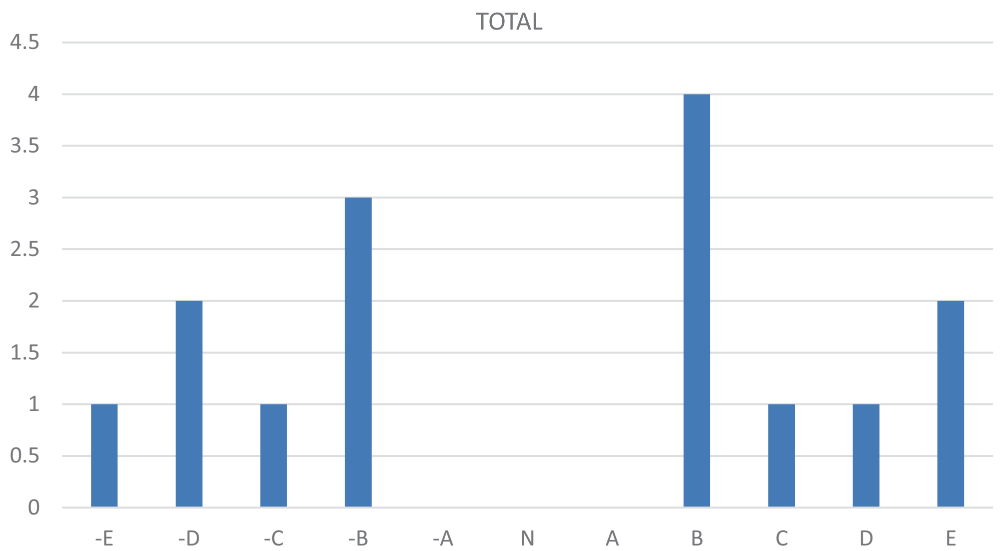


FIGURE 7
Total results.

dimensions in this issue. The total amount of bad environmental effects on the project in the state of coronavirus disease has decreased and improved. Also, the average amount of these effects in the coronavirus era has improved compared to normal conditions. This trend is logical because during the coronavirus era, due to the extensive quarantines of the mentioned items, including reducing the level of pollutants due to greenhouse gas emissions reduction and CO_2 release and the reduction of a loud environment, the damage to the environment has decreased.

Here is a succinct and precise answer to the query based on the search results that were found. According to the search results, the RIAM approach is a helpful resource for carrying out EIAs of different industrial and infrastructural projects, such as parks, landfills, and coal mining. Using a systematic evaluation process, the RIAM method assesses a project's positive and negative environmental consequences across several components, including physical/chemical, biological/ecological, social/cultural, and economic/operational elements. This enables decision-makers to pinpoint the most important environmental effects and create effective mitigation plans. The RIAM technique has been successfully used in several studies to evaluate the environmental effects of projects under typical operating circumstances.

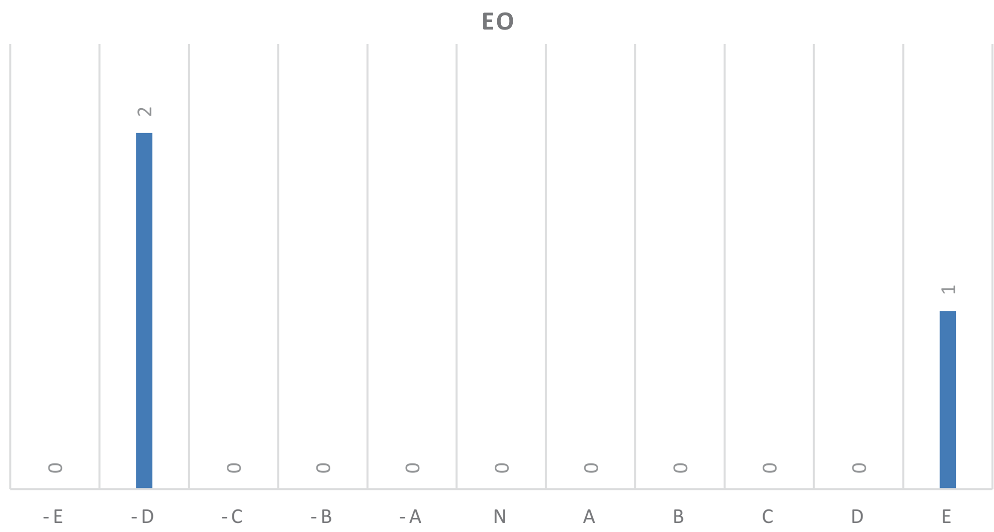
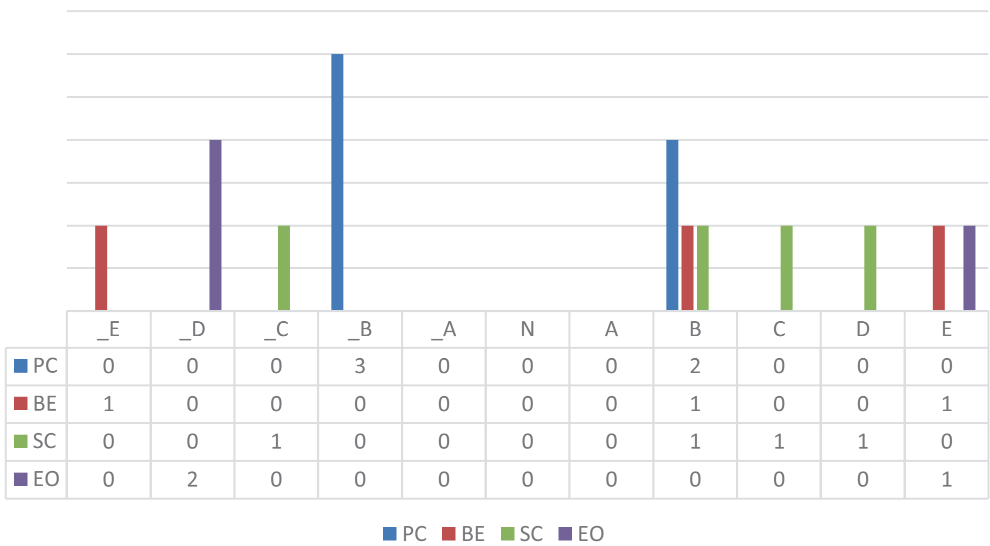


FIGURE 8
RIAM results for the EO components.



	_E	_D	_C	_B	_A	N	A	B	C	D	E
PC	0	0	0	3	0	0	0	2	0	0	0
BE	1	0	0	0	0	0	0	1	0	0	1
SC	0	0	1	0	0	0	0	1	1	1	0
EO	0	2	0	0	0	0	0	0	0	0	1

FIGURE 9
RIAM results for the four components.

Nevertheless, there is little information about the use of RIAM, particularly during disaster crisis.

An EIA would need to take into account any new environmental factors that the COVID-19 pandemic may have brought about, such as adjustments to resource usage, waste creation, or worker safety procedures. The RIAM technique would probably need to be modified to take these particular pandemic-related aspects into account to analyze environmental consequences during the epidemic in a comprehensive manner. In summary, the search results do not directly address how the RIAM technique may be used during the COVID-19 pandemic, even though it is a useful tool for environmental impact assessment. To comprehend the applicability and possible adjustments of RIAM for EIAs carried out in the context of the ongoing public health emergency, more investigation would be required.

Several suggestions can be made for future work. Including the use, of the other methods of evaluating the reset environment and comparing it with the method used in this paper. Increasing the scope of knowledge by examining the number of cities and geographical extent. Establishing other new indicators and expanding these indicators.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

TABLE 3 RIAM analysis during the COVID-19 pandemic.

Components	ES	RB	A1	A2	B1	B2	B3
PC1	+24	+C	2	2	2	2	2
PC2	+12	+B	2	1	2	2	2
PC3	−18	−B	3	−1	3	2	1
PC4	−12	−B	2	−1	3	2	1
PC5	+12	+B	1	+2	3	2	1
PC6	−12	−B	2	−1	3	2	1
BE1	+12	+B	2	+1	3	2	1
BE2	−108	−E	4	−3	3	3	3
BE3	+96	+E	4	+3	3	2	3
SC1	+14	+B	1	+2	3	2	2
SC2	+45	+D	3	+3	3	1	1
SC3	−30	−C	3	−2	3	1	1
EO1	+108	+E	4	+3	3	3	3
EO2	−42	−D	3	−2	2	3	2
EO3	−42	−D	3	−2	2	3	2

TABLE 4 COVID-19 RIAM summary scores.

Class	−E	−D	−C	−B	−A	N	+A	+B	+C	+D	+E
PC	0	0	0	3	0	0	0	2	1	0	0
BE	1	0	0	0	0	0	0	1	0	0	1
SC	0	0	1	0	0	0	0	1	0	1	0
EO	0	2	0	0	0	0	0	0	0	0	1
Total	1	2	1	3	0	0	0	4	1	1	2

Author contributions

SA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. UM: Conceptualization, Formal analysis, Funding acquisition, Investigation, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing, Visualization. HJ: Investigation, Validation, Visualization, Writing – review & editing. IA: Supervision, Validation, Visualization, Writing – review & editing. NK: Methodology, Validation, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. However, the article publication charges of this paper have been supported by UM of the Department of Operations Research, Modibbo Adama University, Yola, Nigeria via the frontiers Journal.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

1. Tushar SR, Alam MFB, Bari AM, Karmaker CL. Assessing the challenges to medical waste management during the COVID-19 pandemic: implications for the environmental sustainability in the emerging economies. *Socio Econ Plan Sci*. (2023) 87:101513. doi: 10.1016/j.seps.2023.101513

2. Ilyas S, Srivastava RR, Kim H. Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. *Sci Total Environ*. (2020) 749:141652. doi: 10.1016/j.scitotenv.2020.141652

3. Wilkinson A, Ali H, Bedford J, Boonyabancha S, Connolly C, Conteh A, et al. Local response in health emergencies: key considerations for addressing the COVID-19 pandemic in informal urban settlements. *Environ Urban*. (2020) 32:503–22. doi: 10.1177/0956247820922843

4. Rubab S, Khan MM, Uddin F, Abbas Bangash Y, Taqvi SAA. A study on AI-based waste management strategies for the COVID-19 pandemic. *ChemBioEng Rev*. (2022) 9:212–26. doi: 10.1002/cben.202100044

5. World Health Organization (2022). Tonnes of COVID-19 healthcare waste exposes the urgent need to improve waste management systems.

6. Uhar I, Luhar S, Abdullah MMAB. Challenges and impacts of COVID-19 pandemic on global waste management systems: a review. *J Compos Sci*. (2022) 6:271. doi: 10.3390/jcs6090271

7. Anazonwu NP, Nnamani KE, Osadebe N, Anichebe O, Ezeibe CC, Mbah PO, et al. State actors, human rights violations and informal livelihoods during the COVID-19 pandemic in Nigeria. *Territ, Politics, Gov*. (2022) 10:876–95. doi: 10.1080/21622671.2021.1976262

8. De Vet J. M., Nigohosyan D., Ferrer J. N., Gross A. K., Kuehl S., Flickenschild M. (2021). *Impacts of the COVID-19 Pandemic on EU Industries*. Strasbourg, France: European Parliament, 1–86

9. Torkashvand J, Jonidi Jafari A, Godini K, Kazemi Z, Kazemi Z, Farzadkia M. Municipal solid waste management during COVID-19 pandemic: a comparison between the current activities and guidelines. *J Environ Health Sci Eng*. (2021) 19:173–9. doi: 10.1007/s40201-020-00591-9

10. Martínez LF, Toro J, León JC. A complex network approach to environmental impact assessment. *Impact Assess Proj Apprais*. (2019) 37:407–20. doi: 10.1080/14615517.2018.1552442

11. Monavari M. (2002). "Environmental impact assessment pattern of municipal solid waste disposal site" in Organization of Tehran Municipality's recycling and conversion materials, Department of Education and Research. Sineh Sorkh Publication, Tehran.

12. Ayeleru OO, Okonta FN, Ntuli F. Municipal solid waste generation and characterization in the City of Johannesburg: a pathway for the implementation of zero waste. *Waste Manag*. (2018) 79:87–97. doi: 10.1016/j.wasman.2018.07.026

13. Khajuria A, Yamamoto Y, Morioka T. Estimation of municipal solid waste generation and landfill area in Asian developing countries. *J Environ Biol*. (2010) 31:649–54.

14. El-Naqa A. Environmental impact assessment using rapid impact assessment matrix (RIAM) for Russeifa landfill, Jordan. *Environ Geol*. (2005) 47:632–9. doi: 10.1007/s00254-004-1188-8

15. Aliakbari-Beidokhti Z, Ghazizade MJ, Gholamalifard M. Environmental impact assessment of municipal solid waste disposal site using rapid impact assessment matrix (RIAM) analysis in Mashhad city, Iran. *Environ Eng Manag J*. (2017) 16:2361.

16. Silsilah UP, Gandhimathi A. Environmental impact assessment (EIA) and prediction method: case study. *J Technic Educ Sci*. (2023) 74:65–74.

17. Ghanbaripour AN, Langston C, Tumpa RJ, Skulmoski G. Validating and testing a project delivery success model in construction: a mixed-method approach in Australia. *Smart Sustain Built Environ*. (2023) 13:532–59. doi: 10.1108/SASBE-09-2022-0200

18. Zhao Y, Chen Y, Lu X, Zhou L, Xiong S. Aerial image recognition in discriminative bi-transformer. *Signal Process*. (2023) 207:108963. doi: 10.1016/j.sigpro.2023.108963

19. Sluser B, Plavan O, Teodosiu C. Environmental impact and risk assessment In: *Assessing Progress Towards Sustainability*: Elsevier (2022), 189–217.

20. Chen T. Communicating appropriate cleaning and disinfection practices and health risks in environmental public health practice. *Environ Health Rev*. (2021) 63:96–100. doi: 10.5864/d2020-026

21. Rand T, Haukohl J, Marxen U. *Municipal Solid Waste Incineration: Requirements for a Successful Project*. vol. *462*. World Bank Publications (2000).

22. Yousefi M, Oskoei V, Jonidi Jafari A, Farzadkia M, Hasham Firooz M, Abdollahinejad B, et al. Municipal solid waste management during COVID-19 pandemic: effects and repercussions. *Environ Sci Pollut Res*. (2021) 28:32200–9. doi: 10.1007/s11356-021-14214-9

23. Ahmadini AAH, Modibbo UM, Shaikh AA, Ali I. Multi-objective optimization modelling of sustainable green supply chain in inventory and production management. *Alex Eng J*. (2021) 60:5129–46.

24. Kalantary S, Khadem M, Golbabaei F. Personal protective equipment for protecting healthcare staff during COVID-19 outbreak: a narrative review. *Front Emerg Med*. (2020) 4:e61.

25. Mahyari KF, Sun Q, Klemeš JJ, Aghbashlo M, Tabatabaei M, Khoshnevisan B, et al. To what extent do waste management strategies need adaptation to post-COVID-19? *Sci Total Environ*. (2022) 837:155829. doi: 10.1016/j.scitotenv.2022.155829

26. Wilkins H. The need for subjectivity in EIA: discourse as a tool for sustainable development. *Environ Impact Assess Rev*. (2003) 23:401–14. doi: 10.1016/S0195-9255(03)00044-1

27. del Carmen Munguía-López A, Ochoa-Barragán R, Ponce-Ortega JM. Optimal waste management during the COVID-19 pandemic. *Chem Eng Process Process Intensif*. (2022) 176:108942. doi: 10.1016/j.cep.2022.108942

28. Roy P, Mohanty AK, Wagner A, Sharif S, Khalil H, Misra M. Impacts of COVID-19 outbreak on the municipal solid waste management: now and beyond the pandemic. *ACS Environ*. (2021) 1:32–45. doi: 10.1021/acsenvironau.1c00005

29. Mihai FC. Assessment of COVID-19 waste flows during the emergency state in Romania and related public health and environmental concerns. *Int J Environ Res Public Health*. (2020) 17:5439. doi: 10.3390/ijerph17155439

30. Aragaw TA, Mekonnen BA. Current plastics pollution threats due to COVID-19 and its possible mitigation techniques: a waste-to-energy conversion via pyrolysis. *Environ Syst Res*. (2021) 10:1–11. doi: 10.1186/s40068-020-00217-x

31. Hantoko D, Li X, Pariatamby A, Yoshikawa K, Horttanainen M, Yan M. Challenges and practices on waste management and disposal during the COVID-19 pandemic. *J Environ Manag*. (2021) 286:112140. doi: 10.1016/j.jenvman.2021.112140

32. Manzoor J, Sharma M. Impact of biomedical waste on the environment and human health. *Environ Claims J*. (2019) 31:311–34. doi: 10.1080/10406026.2019.1619265

33. Das AK, Islam MN, Billah MM, Sarker A. COVID-19 pandemic and healthcare solid waste management strategy–a mini-review. *Sci Total Environ*. (2021) 778:146220. doi: 10.1016/j.scitotenv.2021.146220

34. Molloy S, Varkey P, Walker TR. Opportunities for a single-use plastic reduction in the food service sector during COVID-19. *Sustain Product Consump*. (2022) 30:1082–94. doi: 10.1016/j.spc.2022.01.023

35. Lyu W, Wehby GL. Community use of face masks and COVID-19: evidence from a natural experiment of state mandates in the US: the study examines the impact on COVID-19 growth rates associated with state government mandates requiring face mask use in public. *Health Aff*. (2020) 39:1419–25. doi: 10.1377/hlthaff.2020.00818

36. Fadare OO, Okoffo ED. Covid-19 face masks: a potential source of microplastic fibers in the environment. *Sci Total Environ*. (2020) 737:140279. doi: 10.1016/j.scitotenv.2020.140279

37. Ibn-Mohammed T, Mustapha KB, Godsell J, Adamu Z, Babatunde KA, Akintade DD, et al. A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. *Resour Conserv Recycl*. (2021) 164:105169. doi: 10.1016/j.resconrec.2020.105169

38. Haque MS, Sharif S, Masnoon A, Rashid E. SARS-CoV-2 pandemic-induced PPE and single-use plastic waste generation scenario. *Waste Manag Res*. (2021) 39:3–17. doi: 10.1177/0734242X20980828

39. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol*. (2011) 32:687–99. doi: 10.1086/660363

40. Pinto AD, Jalloul H, Nickdoost N, Sanusi F, Choi J, Abichou T. Challenges and adaptive measures for US municipal solid waste management systems during the COVID-19 pandemic. *Sustain For*. (2022) 14:4834. doi: 10.3390/su14084834

41. Nabavi-Pelesaraei A, Mohammadkashi N, Naderloo L, Abbasi M, Chau KW. Principal of environmental life cycle assessment for medical waste during the COVID-19 outbreak to support sustainable development goals. *Sci Total Environ*. (2022) 827:154416. doi: 10.1016/j.scitotenv.2022.154416

42. Magid HC, Rasheed HS, Al-Wardy RA. Effect of doping with zinc oxide on the structural, surface, and optical properties of titanium dioxide thin films. *Reason*. (2023) 29:5.

43. Chen M, Shi Y, Zhu L. Application of generative adversarial network in image color correction. *Int J Image Graph*. (2024) 2550069:25–69. doi: 10.1142/S021946782550069X

44. Younis YS, Ali AH, Alhafidhb OKS, Yahia WB, Alazzam MB, Hamad AA, et al. Early diagnosis of breast cancer using image processing techniques. *J Nanomater*. (2022) 2022:1–6. doi: 10.1155/2022/2641239

45. Enbeyle W, Hamad AA, Al-Obaidi AS, Abebaw S, Belay A, Markos A, et al. Trend analysis and prediction on water consumption in southwestern Ethiopia. *J Nanomater*. (2022) 2022:1–7. doi: 10.1155/2022/3294954

46. Smeein SB, Shihab S, Delphi M. Operational spline scaling functions method for solving optimal control problems. *Samarra J Pure Appl Sci*. (2023) 5:160–172.

47. Faris A, Badamasi M. Feasibility of breast cancer detection through a convolutional neural network in mammographs. *Tamjeed J Healthc Eng Sci Technol*. (2023) 1:36–43.

48. Ahmed FM, Mohammed BS. Feasibility of breast cancer detection through a convolutional neural network in mammographs. *Tamjeed J Healthcare Eng Sci Technol*. (2023) 1:36–43. doi: 10.59785/tjhest.v1i2.24

49. Bonnici V, Cicceri G, Distefano S, Galletta L, Polignano M, Scaffidi C. Covid19/IT the digital side of Covid19: a picture from Italy with clustering and taxonomy. *PLoS One*. (2022) 17:e0269687. doi: 10.1371/journal.pone.0269687

50. Torres Martín C, Acal C, El Homrani M, Mingorance Estrada ÁC. Impact on the virtual learning environment due to COVID-19. *Sustain For*. (2021) 13:582. doi: 10.3390/su13020582

51. Cardenas ICIC, Halman JIMJIMJ. Coping with uncertainty in environmental impact assessments: open techniques. *Environ Impact Assess Rev*. (2016) 60:24–39. doi: 10.1016/j.eiar.2016.02.006

52. Caro-Gonzalez AL, Nita A, Toro J, Zamorano M. From procedural to transformative: a review of the evolution of effectiveness in EIA. *Environ Impact Assess Rev*. (2023) 103:107256. doi: 10.1016/j.eiar.2023.107256

53. Caro-Gonzalez AL, Toro J, Zamorano M. Effectiveness of environmental impact statement methods: a Colombian case study. *J Environ Manag*. (2021) 300:113659. doi: 10.1016/j.jenvman.2021.113659

54. Kamal A, Burkell J. Uncertainty: when information is not enough. *Can J Inf Libr Sci*. (2011) 4:384–96.

55. Leung W, Noble B, Gunn J, Jaeger JAGG. A review of uncertainty research in impact assessment. *Environ Impact Assess Rev*. (2015) 50:116–23. doi: 10.1016/j.eiar.2014.09.005

56. Loomis JJ, Dziedzic M. Evaluating EIA systems' effectiveness: a state of the art. *Environ Impact Assess Rev*. (2018) 68:29–37. doi: 10.1016/j.eiar.2017.10.005

57. Pastakia CMR, Jensen A. The rapid impact assessment matrix (Riam) for environmental impact assess. *Review*. (1998) 18:461–82. doi: 10.1016/S0195-9255(98)00018-3(98)00018-3

58. Tennøy A. Consequences of EIA prediction uncertainty on mitigation, follow-up and post-auditing In: M Schmidt, J Glasson, L Emmelin and H Helbron, editors. *Standards and Thresholds for Impact Assessment*. Berlin/Heidelberg: Springer (2008). 447–61.

59. Tennøy A, Kværner J, Gjerstad K. Uncertainty in environmental impact assessment predictions: the need for better communication and more transparency. *Impact Assess Proj Apprais*. (2006) 24:45–56. doi: 10.3152/147154606781765345

60. Veronez F.-A., Montaño M., (2015). "EIA effectiveness: Conceptual basis for an integrative approach" in *IAIA15 Conference Proceedings: Impact Assessment in the Digital Era. 35th Annual Conference of International Association for Impact Assessment*. p. 6.

61. Leal Filho W, Lange Salvia A, Sierra J, Fletcher CA, Banks CE, Velazquez L, et al. COVID-19 and households waste in Hispanic America: an assessment of trends. *Sustain For*. (2022) 14:16552. doi: 10.3390/su142416552

62. Barma M, Biniyamin HK, Modibbo UM, Gaya HMA. Mathematical model for the optimization of municipal solid waste management. *Front Sustain*. (2022) 3:880409. doi: 10.3389/frsus.2022.880409

63. Clavreul J, Baumeister H, Christensen TH, Damgaard A. An environmental assessment system for environmental technologies. *Environ Model Softw*. (2014) 60:18–30. doi: 10.1016/j.envsoft.2014.06.007

64. Bhar A, Biswas RK, Choudhury AK. The influence of the COVID-19 pandemic on biomedical waste management, the impact beyond infection. *Proc Indian Natl Sci Acad*. (2022) 88:117–28. doi: 10.1007/s43538-022-00070-9

65. Yuan X, Wang X, Sarkar B, Ok YS. The COVID-19 pandemic necessitates a shift to a plastic circular economy. *Nat Rev Earth Environ*. (2021) 2:659–60. doi: 10.1038/s43017-021-00223-2

66. Udaykumar MS, Vazhacharickal PJ, Bellundagi V, Hamsa KR, Umesh KB. Atma Nirbhar and other agricultural relief packages with a special focus on the COVID-19 pandemic situation in India. *History*. (2019) 2:59.

67. Maghrebi M, Danandeh Mehr A, Karrabi SM, Sadegh M, Partani S, Ghiasi B, et al. Spatiotemporal variations of air pollution during the COVID-19 pandemic across Tehran, Iran: commonalities with and differences from global trends. *Sustain For*. (2022) 14:16313. doi: 10.3390/su142316313

68. Tanvir S, Ravichandran D, Ivey C, Barth M, Boriboonsomsin K. Traffic, air quality, and environmental justice in the south coast air basin during California's COVID-19 shutdown In: A Loukaitou-Sideris, AM Bayen, G Circella, R Jayakrishnan, editors. *Pandemic in the Metropolis: Transportation Impacts and Recovery*. Cham: Springer International Publishing (2023). 131–48.

69. Zand AD, Heir AV. Environmental impacts of new coronavirus outbreak in Iran with an emphasis on waste management sector. *J Mater Cycles Waste Manag*. (2021) 23:240–7.

70. Zand AD, Heir AV, Tabrizi AM. Investigation of knowledge, attitude, and practice of Tehrani a woman apropos of reducing, reusing, recycling, and recovery of urban solid waste. *Environ Monit Assess*. (2020) 192:1–13.

71. Abbasi S, Sıcakyüz Ç, Erdebilli B. Designing the home healthcare supply chain during a health crisis. *J Eng Res*. (2023) 11:100098. doi: 10.1016/j.jer.2023.100098

72. Abbasi S, Daneshmand-Mehr M, Ghane Kanafi A. Green closed-loop supply chain network design during the coronavirus (COVID-19) pandemic: a case study in the Iranian automotive industry. *Environ Model Assess*. (2023) 28:69–103. doi: 10.1007/s10666-022-09863-0

73. Ahmadi SA, Mirlohi SM, Ahmadi MH, Ameri M. Portfolio optimization of power plants by using renewable energy in Iran. *Int J Low-Carbon Technol*. (2021) 16:463–75. doi: 10.1093/ijlct/ctaa079

74. Danladi S, Prasad MSV, Modibbo UM, Ahmadi SA, Ghasemi P. Attaining sustainable development goals through financial inclusion: exploring collaborative approaches to Fintech adoption in developing economies. *Sustain For*. (2023) 15:13039. doi: 10.3390/su151713039

75. Shirazi H, Kia R, Ghasemi P. A stochastic bi-objective simulation–optimization model for plasma supply chain in case of COVID-19 outbreak. *Appl Soft Comput*. (2021) 112:107725. doi: 10.1016/j.asoc.2021.107725

76. Abbasi S, Choukolaei HA. A systematic review of green supply chain network design literature focusing on carbon policy. *Decis Analy J*. (2023) 6:100189. doi: 10.1016/j.dajour.2023.100189

77. Goodarzian F, Garjan HS, Ghasemi P. A state-of-the-art review of operation research models and applications in home healthcare. *Healthcare Analy*. (2023) 4:100228. doi: 10.1016/j.health.2023.100228

78. Ghasemi P, Goodarzian F, Simic V, Tirkolaee EB. A DEA-based simulation-optimisation approach to design a resilience plasma supply chain network: a case study of the COVID-19 outbreak. *Int J Syst Sci: Oper Logist*. (2023) 10:2224105.

79. Abbasi S, Daneshmand-Mehr M, Ghane Kanafi A. Designing sustainable recovery network of end-of-life product during the COVID-19 pandemic: a real and applied case study. *Discret Dyn Nat Soc*. (2022) 2022:1–21. doi: 10.1155/2022/6967088

80. Shirazi H, Kia R, Ghasemi P. Ranking of hospitals in the case of COVID-19 outbreak: a new integrated approach using patient satisfaction criteria. *Int J Healthc Manag*. (2020) 13:312–24. doi: 10.1080/20479700.2020.1803622

81. Abbasi S, Erdebilli B. Green closed-loop supply chain networks' response to various carbon policies during COVID-19. *Sustain For*. (2023) 15:3677. doi: 10.3390/su15043677

82. Ahmadi SA, Ghasemi P. Pricing strategies for online hotel searching: a fuzzy inference system procedure. *Kybernetes*. (2023) 52:4913–36. doi: 10.1108/K-03-2022-0427

83. Abbasi S, Daneshmand-Mehr M, Ghane Kanafi A. The sustainable supply chain of CO_2 emissions during the coronavirus disease (COVID-19) pandemic. *J Ind Eng Int*. (2021) 17:83–108. doi: 10.30495/JIEI.2022.1942784.1169

84. Momenitabar M, Ebrahimi ZD, Ghasemi P. Designing a sustainable bioethanol supply chain network: a combination of machine learning and meta-heuristic algorithms. *Ind Crop Prod*. (2022) 189:115848. doi: 10.1016/j.indcrop.2022.115848

85. Abbasi S, Khalili HA, Daneshmand-Mehr M, Hajiaghaei-Keshteli M. Performance measurement of the sustainable supply chain during the COVID-19 pandemic: a real-life case study. *Found Comput Decis Sci*. (2022) 47:327–58. doi: 10.2478/fcds-2022-0018

86. Ahmadi SA, Peivandizadeh A. Sustainable portfolio optimization model using promethee ranking: a case study of palm oil buyer companies. *Discret Dyn Nat Soc*. (2022) 2022:1–11. doi: 10.1155/2022/8935213

87. Abbasi S, Zahmatkesh S, Bokhari A, Hajiaghaei-Keshteli M. Designing a vaccine supply chain network considering environmental aspects. *J Clean Prod*. (2023) 417:137935. doi: 10.1016/j.jclepro.2023.137935

88. Abbasi S, Daneshmand-Mehr M, Kanafi AG. Designing a tri-objective, sustainable, closed-loop, and multi-echelon supply chain during the COVID-19 and lockdowns. *Found Comput Decis Sci*. (2023) 48:269–312. doi: 10.2478/fcds-2023-0011

89. Khalili-Damghani K, Ghasemi P. Uncertain centralized/decentralized production-distribution planning problem in multi-product supply chains: fuzzy mathematical optimization approaches. *Indus Eng Manag Syst*. (2016) 15:156–72. doi: 10.7232/iems.2016.15.2.156

90. Abbasi S, Vlachos I, Rekabi S, Talooni M. Designing the distribution network of essential items in the critical conditions of earthquakes and COVID-19 simultaneously. *Sustain For*. (2023) 15:15900. doi: 10.3390/su152215900

91. Gonzalez EDS, Abbasi S, Azhdarifard M. Designing a reliable aggregate production planning problem during the disaster period. *Sustain Operat Comp*. (2023) 4:158–71. doi: 10.1016/j.susoc.2023.08.004

92. Goodarzian F, Kumar V, Ghasemi P. Investigating a citrus fruit supply chain network considering CO2 emissions using meta-heuristic algorithms. *Ann Oper Res*. (2022) 317:1–57. doi: 10.1007/s10479-022-05005-7

93. Abbasi S, Moosivand M, Vlachos I, Talooni M. Designing the location–routing problem for a cold supply chain considering the COVID-19 disaster. *Sustain For*. (2023) 15:15490. doi: 10.3390/su152115490

94. Abbasi S, Vlachos I, Samadzadeh A, Etemadifar S, Afshar M, Amra M. Modelling a logistics and financial supply chain network during the COVID-19 era. *Logistics*. (2024) 8:32. doi: 10.3390/logistics8010032

95. Goodarzian F, Ghasemi P, Gunasekaran A, Labib A. A fuzzy sustainable model for COVID-19 medical waste supply chain network. *Fuzzy Optim Decis Making*. (2024) 23:93–127. doi: 10.1007/s10700-023-09412-8

96. Abbasi S, Sıcakyüz Ç. A review of the COVID-19 pandemic's effects and challenges on worldwide waste management for sustainable development. *Int J Environ Sci Technol*. (2024) 21:1–30. doi: 10.1007/s13762-024-05610-y

97. Kahlert S, Bening CR. Plastics recycling after the global pandemic: resurgence or regression? *Resour Conserv Recycl*. (2020) 160:104948. doi: 10.1016/j.resconrec.2020.104948

98. Nzediegwu C, Chang SX. Improper solid waste management increases the potential for COVID-19 spread in developing countries. *Resour Conserv Recycl*. (2020) 161:104947. doi: 10.1016/j.resconrec.2020.104947

99. Corburn J, Vlahov D, Mberu B, Riley L, Caiaffa WT, Rashid SF, et al. Slum health: arresting COVID-19 and improving well-being in urban informal settlements. *J Urban Health*. (2020) 97:348–357.

100. Dente SMR, Hashimoto S. COVID-19: a pandemic with positive and negative outcomes on resource and waste flows and stocks. *Resour Conserv Recycl*. (2020) 161:104979. doi: 10.1016/j.resconrec.2020.104979

101. Zand AD, Heir AV. Emanating challenges in urban and healthcare waste management in Isfahan, Iran after the outbreak of COVID-19. *Environ Technol*. (2021) 42:329–36. doi: 10.1080/09593330.2020.1866082

102. Hemidat S, Achouri O, El Fels L, Elagroudy S, Hafidi M, Chaouki B, et al. Solid waste management in the context of a circular economy in the MENA region. *Sustain For*. (2022) 14:480. doi: 10.3390/su14010480

103. Tsai W-T. Analysis of medical waste management and impact analysis of COVID-19 on its generation in Taiwan. *Waste Manag Res*. (2021):0734242X21996803

104. Zhou C, Yang G, Ma S, Liu Y, Zhao Z. The impact of the COVID-19 pandemic on waste-to-energy and waste-to-material industry in China. *Renew Sust Energ Rev*. (2021) 139:110693. doi: 10.1016/j.rser.2020.110693

105. Zambrano-Monserrate MA, Ruano MA, Sanchez-Alcalde L. Indirect effects of COVID-19 on the environment. *Sci Total Environ*. (2020) 728:138813. doi: 10.1016/j.scitotenv.2020.138813

106. Zhao H, Liu H, Wei G, Zhang N, Qiao H, Gong Y, et al. A review on emergency disposal and management of medical waste during the COVID-19 pandemic in China. *Sci Total Environ*. (2022) 810:152302. doi: 10.1016/j.scitotenv.2021.152302

107. Rume T, Islam SDU. Environmental effects of COVID-19 pandemic and potential strategies of sustainability. *Heliyon*. (2020) 6:e04965. doi: 10.1016/j.heliyon.2020.e04965

108. Tondelli S, Farhadi E, Akbari Monfared B, Ataeian M, Tahmasebi Moghaddam H, Dettori M, et al. Air quality and environmental effects due to COVID-19 in Tehran, Iran: lessons for sustainability. *Sustain For*. (2022) 14:15038.

109. Rassouli M, Ashrafizadeh H, Shirinabadi Farahani A, Akbari ME. COVID-19 management in Iran as one of the most affected countries in the world: advantages and weaknesses. *Front Public Health*. (2020) 8:510. doi: 10.3389/fpubh.2020.00510

110. Pourghaznein T, Salati S. The national approach in response to the COVID-19 pandemic in Iran. *Int J Commun Nurs Midwifery*. (2020) 8:275–6. doi: 10.30476/IJCBNM.2020.85928.1308

111. Available at: https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-mask

112. Samimiardestani S, Sharifi M, Ranjbar MF. Personal protective equipment usage among Iranian police officers during COVID-19 pandemic; a cross-sectional study. *Front Emerg Med*. (2023) 7:e5. doi: 10.18502/fem.v7i1.11695

113. Hossini H, Atashkar S, Massahi T. Face mask consumption and medical waste generation during the COVID-19 pandemic in Iran: challenges and problems. *Int J Health Life Sci*. (2021) 7. doi: 10.5812/ijhls.115046

114. Allahyari MS, Marzban S, El Bilali H, Hassen TB. Effects of COVID-19 pandemic on household food waste behavior in Iran. *Heliyon*. (2022) 8:e11337. doi: 10.1016/j.heliyon.2022.e11337

115. World Health Organization. (2020). Advice on the use of masks in the context of COVID-19: interim guidance, 6 April 2020 (No. WHO/2019-nCov/IPC_Masks/2020.3). World Health Organization.

116. Rahman MZ, Hoque ME, Alam MR, Rouf MA, Khan SI, Xu H, et al. Face masks to combat coronavirus (covid-19)—processing, roles, requirements, efficacy, risk and sustainability. *Polymers*. (2022) 14:1296. doi: 10.3390/polym14071296

117. Fixler AL, Jacobs LA, Jones DB, Arnold A, Underwood EE. There goes the neighborhood? The public safety enhancing effects of a mobile harm reduction intervention. *Int J Drug Policy*. (2024) 124:104329. doi: 10.1016/j.drugpo.2024.104329

118. Bolwig S., Tanner A. N., Riemann P., Redlingshöfer B., Zhang Y. (2021). Reducing consumer food waste using green and digital technologies.

119. Rupani PF, Maleki Delarestaghi R, Asadi H, Rezania S, Park J, Abbaspour M, et al. Current scenario of the Tehran municipal solid waste handling rules towards green technology. *Int J Environ Res Public Health*. (2019) 16:979. doi: 10.3390/ijerph16060979

120. Jaafari J, Dehghani MH, Hoseini M, Safari GH. Investigation of hospital solid waste management in Iran. *World Rev Sci Technol Sustain Dev*. (2015) 12:111–25. doi: 10.1504/WRSTSD.2015.073820

121. Valizadeh J, Hafezalkotob A, Alizadeh SMS, Mozafari P. Hazardous infectious waste collection and government aid distribution during COVID-19: a robust mathematical leader-follower model approach. *Sustain Cities Soc*. (2021) 69:102814. doi: 10.1016/j.scs.2021.102814

122. Available at: https://www.who.int/teams/health-product-policy-and-standards/assistive-and-medical-technology/medical-devices/ppe/ppe-covid

123. Raoofi A, Takian A, Sari AA, Olyaeemanesh A, Haghighi H, Aarabi M. COVID-19 pandemic and comparative health policy learning in Iran. *Arch Iran Med*. (2020) 23:220–34. doi: 10.34172/aim.2020.02

124. Zand AD, Heir AV. Emerging challenges in urban waste management in Tehran, Iran during the COVID-19 pandemic. *Resour Conserv Recycl*. (2020) 162:105051. doi: 10.1016/j.resconrec.2020.105051

125. Available at: https://www.who.int/news/item/13-01-2023-who-updates-covid-19-guidelines-on-masks--treatments-and-patient-care

126. Kumar R, Verma A, Shome A, Sinha R, Sinha S, Jha PK, et al. Impacts of plastic pollution on ecosystem services, sustainable development goals, and the need to focus on circular economy and policy interventions. *Sustain For*. (2021) 13:9963. doi: 10.3390/su13179963

127. Mol MPG, Caldas S. Can the human coronavirus epidemic also spread through solid waste? *Waste Manag Res*. (2020) 38:485–6. doi: 10.1177/0734242X20918312

128. Upham P, Thomas C, Gillingwater D, Raper D. Environmental capacity and airport operations: current issues and future prospects. *J Air Transp Manag*. (2003) 9:145–51. doi: 10.1016/S0969-6997(02)00078-9

129. Ali I, Charles V, Modibbo UM, Gherman T, Gupta S. Navigating COVID-19: unraveling supply chain disruptions through best-worst method and fuzzy TOPSIS. *Bijdragen*. (2023). doi: 10.1108/BIJ-11-2022-0708

130. Barma M, Modibbo UM. Multiobjective mathematical optimization model for municipal solid waste management with economic analysis of reuse/recycling recovered waste materials. *J Computat Cogn Eng*. (2022) 1:122–37. doi: 10.47852/bonviewJCCE149145