OPEN ACCESS Freely available online

International Journal of
Waste Resources

ISSN: 2252-5211

Research Article

Applying Circular Economy in Municipal Waste Management by Optimal Approach of Game Theory

Gholamhossein Lari*

Safety and Fire Fighting Organization, Shiraz Municipality, Shiraz, Iran

ABSTRACT

Today, industrial infrastructure societies are constantly changing. The presence of waste and municipal waste from industrial areas raises environmental concerns. Therefore, there is a need for new and optimal tools and methods to reduce the negative environmental and economic consequences. This research presents a new and optimal method to support industrial producers in various fields, especially food, to manage industrial waste as much as possible. The approach of this research is to provide an optimal structure of circular economics based on game theory that determines an adaptive decision structure based on fixed risk assessment and current knowledge. Adaptive decision-making structure based on game theory in the structure of the circular economy is a structural process for learning, improving understanding and finally adapting management decisions in a regular and efficient manner with the aim of reducing uncertainty during the management period. This research, by explicitly recognizing situational developments and improving decisions through learning, has great potential to meet future challenges in managing industrial risk and waste. This approach has been proposed as a way to re-evaluate risks and provide more adaptive and flexible management measures to strengthen infrastructure in the face of change. Sequential and adaptive updating of game theory is considered to reduce uncertainty and provide a decision management system. Finally, the proposed comparative decision-making method with a criterion based on a residential community as an industrial project in Tehran is shown to examine its feasibility and effectiveness in managing evolving risks. The results of this study show that changes in risk and vulnerability increase future risks for society and such risks can be managed with adaptive decision management system.

Keywords: Industrial waste management; Decision management system; Game theory; Comparative decision management

INTRODUCTION

Achieving global food security is a challenge that requires the creation of a range of actions by countless actors, including global organizations, governments, NGOs, food companies, retailers and consumers. An approach is needed to increase the availability of food for low-income communities, reduce the amount of food waste and divert food surpluses to those in need. It is estimated that only 25% of global food waste is sufficient to feed all hungry people worldwide [1]. In the UK, most food waste is generated in only two stages of the supply chain: during production and during consumption. Currently, several schemes seek to raise consumer awareness of the cost of food waste and provide advice on how to prevent food wastage (for example, food waste [2]). However, there are fewer joint efforts to reduce food waste from producers, so food companies often have to identify and implement their waste management and prevention solutions. As a result, the food industry often manages its food waste in non-optimal ways, basing its decision on a limited number of factors such as cost, access to waste management facilities, and the need for resources to implement solutions. In addition, large portions of industrial food waste are unavoidable [3], commonly known as food by-products, implying the management of food waste rather than precautionary measures in some cases. Food waste management options in the UK food industry have been measured [4,5], and based on these two studies, it is concluded that most industrial food waste in the UK cannot be reduced (ie this is inevitable).) And a wide range of different food waste management is required, covering all levels of the food waste management hierarchy. At present, almost half of food waste management (including foodstuffs) is offered in the UK

***Corresponding to**: Gholamhossein Lari, Safety and Fire Fighting Organization, Shiraz Municipality, Shiraz, Iran, Tel: 98-9173004788; E-mail: gh.lari@gmail.com

Received: December 31, 2020; **Accepted:** January 12, 2021; **Published:** January 20, 2021

Citation: Lari G (2021) Applying Circular Economy in Municipal Waste Management by Optimal Approach of Game Theory. Int J Waste Resour 11: 393. doi: 10.35248/2252-5211.21.11.393

supply chain during the production phase [4].

There is little information on waste produced in the rest of Europe [6]. It should be noted that different definitions and methods are used to quantify industrial waste in different regions. A coordinated method for quantifying industrial waste in the supply chain that should be followed to compare the results of different countries has recently been published by FUSIONS [7]. The high variation in the proportion of waste in the industrial stage of developed supply chains can be attributed to the size of the food industry sector in the region, the type of food produced (e.g. perishable or preservative foods), various regulations and government encouragement. Waste reduction was examined.

Terms used for coexistence-based life cycle management include "circular economics", "Nash theory ", "factor-based model", "multi-criteria analysis"."Scenario analysis", "robust decision making", "integrated evaluation model" and each of the combined methods with "circular economy" and "solid waste" are the secondary parts of this research. Including factor-based modeling, multi-criteria decision analysis, scenario analysis, robust decision management, and cumulative modeling are useful for analyzing the process of the decision management system, but they do not take into account the strategic behavior of the actors involved in the negotiation. In contrast, Nash's theory provides a valuable insight into how actors' preferences and decisions influence the choice of their opponents, their subsequent decisions, and the end results of strategic interaction. For example, if one of the participants significantly as Propose a way to persuade competitors to submit more bids. The price at which it is sold may be different from if two or more bidders gradually volunteer to bring one to the maximum perceived value. One of the advantages of Nash theory is that it considers people's behavior based on their interests in practice and seeks the optimal result of the system of individual selfish behaviors.

As a result, a large number of articles have been published to address this issue and suggest software solutions or decision support tools. In [8] an extensive review of simulation and optimization models for solid waste management prepared before 2010, which shows the lack of a complete approach to the waste management cycle. Decision-making tools focused on waste management sustainability issues have been proposed by various authors [9-11]. In [12] discusses different models of decision support focusing on the application of theoretical game methods. Also [13] examines the methods of game theory and introduces a system for evaluating the impact of waste technologies on energy. Other research has been done in this field, such as [14] and [15], which have used a randomized fuzzy programming approach.

EXAMINING THE EVOLVING CONDITIONS AND THEIR IMPACT ON THE PERFORMANCE OF INDUSTRIAL INFRASTRUCTURE PROJECTS AND COMMUNITIES

In routine potential risk assessment and risk-conscious decision-making, the performance of industrial infrastructure projects and communities is often assessed based on current perceptions of capacity and demand. In most cases, such analyzes may not explain the dynamic changes in the three components of risk (exposure to vulnerability) as well as the impact on external factors such as social, economic, political, and environmental conditions, which over time may even Evolve and will have an impact. The performance of global climate change may affect both the frequency and severity of hazardous natural disasters for industrial infrastructure projects and communities. As the population and the value of assets in hazardous areas increase, the exposure to these risks increases. Structural vulnerability increases due to material deterioration, deterioration or spread of industrial waste deterioration. Changes in social and political conditions and preferences are expected in the future. The level and speed of future technology development is likely to change over time, and there is considerable ambiguity and uncertainty about economic forecasts, such as the rate of economic growth and the amount of capital accumulated. The above evolutionary factors and their potential impacts should be understood and incorporated in the evaluation of the performance of construction infrastructure projects and communities to properly manage the associated risks and to support flexible decision-making. Risk assessment and risk-aware decision making without considering these dynamic conditions may lead to the achievement and reduction of future risk values.

Evolving conditions along with the operation of industrial systems and infrastructure

There are different types of evolving conditions that affect the performance of industrial infrastructure systems and communities. Some examples are given in the following section. However, it is worth noting that the criterion problem presented in Section 4 is only exposure to vulnerabilities and industrial waste management.

Increased frequency and severity of danger due to global climate change: In recent years, there is growing evidence that global climate change may affect both the frequency and severity of severe natural disasters, which in turn affect loading frequency and intensity in infrastructure systems[16] which can provide a risk factor for industrial waste in various environments, especially residential areas. Climate change, including temperature, humidity, and CO_2 concentrations, can also affect the durability of wastes that are exposed to chloride, carbonate, or corrosion ingress [17,18]. The potential impact of climate change risks on industrial infrastructure facilities, especially the wastewater sector, is likely to be a major concern for regulators and other decision-makers. The Industrial Engineering Research Society is beginning to investigate such effects on the structural load and risk of industrial infrastructure [4,5]. The American Society of Industrial Engineers has also set up a Climate Change Adaptation Committee to consider the potential impact of climate change on the design of industrial waste infrastructure, something that has not been done in Iran to date.

Increased exposure to hazards: With increasing population and economic development along with urbanization in vulnerable areas of the world, exposure to risks also increases. For example, the population in the northern and central parts of Tehran is still growing, such areas also suffer from natural hazards such as earthquakes. The presence of natural disasters such as earthquakes can accumulate industrial waste in an environment and lead to environmental hazards. As a result, communities in those areas are growing over time by adding more housing and support facilities. In addition, economic development also increases the value of assets in those areas.

Increase in vulnerability: Vulnerability of industrial sectors, especially its wastewater sector, changes over time due to material wear, lack of retrofitting and other issues. Improved construction standards make some structures less vulnerable. However, in many developing countries, structural vulnerabilities increase over time due to uncontrolled building practices and unplanned development. In some developing countries, households start with simple one- or two-story shelters that expand vertically or horizontally over time due to population growth and urbanization. Such incremental expansion increases the seismic vulnerability of buildings and ultimately affects the resilience of the community that supports them [1]. The criterion problem used to show the framework of the adaptive decision management system is the expansion of incremental building in a growing residential community located in the northern part of Tehran. Details of evolving hazards and their impact on the life cycle performance of industrial systems and infrastructure are also provided in Section 4.

Developments in social expectations: Public safety is of particular importance in the development of structural code, and ensuring minimal risk to human safety is the first concern in the general regulation of the built environment. However, there is growing awareness of this issue as a result of recent experiences with natural disasters and the new pattern of performance-based engineering that emphasizes the need to minimize social and commercial disruptions and the huge economic losses associated with infrastructure performance. Emphasizes. In addition, in recent years, sustainability and flexibility have been increasingly emphasized in infrastructure design and maintenance decisions. Similarly, people's expectations of the performance of industrial infrastructure have changed over the past few decades, and accordingly, design codes and standards must eventually be adjusted to meet changing social expectations and preferences [19].

Technology advancement: Over the past few decades, technology has progressed faster than ever and improved the performance of industrial infrastructure systems. Future technological changes are expected to affect system robustness (e.g., use of new materials, new designs and industrial techniques, etc.), inspection, maintenance, and alternatives to existing systems, e.g., through improvements in monitoring. On structural health, non-destructive inspection, and maintenance and replacement technologies and system resistance (for example, due to advanced disaster recovery strategies and techniques or advanced modeling).

Economic trends: Industrial infrastructure systems are constantly challenged by resource constraints in their life cycle. The purpose of risk-based management and decision-making is to find the optimal solution among a set of other options that, due to limited resources, maximize performance or social goals or, while meeting various constraints, reduce costs. Thus, optimization processes in decision-making about infrastructure design and maintenance are affected by the amount of resources available, which are very uncertain in the future. In addition, the evaluation of alternative strategies and investments is very sensitive to the discount rate estimated by future economic growth. If developments in economic trends turn into decisions, the optimal choice can be different from the proposed method with conventional methods and achieve better results for the decision management system for industrial projects.

Life cycle performance of industrial infrastructure systems and communities in response to evolving conditions

The potential transformation conditions discussed in the previous sections should be considered in evaluating the life cycle performance of industrial systems and infrastructure to reduce evolving hazards and improve their ability to respond successfully to changing conditions. The life cycle performance characteristics of an industrial project are conceptually shown in Figure 1. An existing infrastructure system deteriorates over time due to wear and tear of building materials due to operating conditions or service environments. The rate of degradation, which is the slope of the gradual decrease in Figure 1, depends on the properties of the material and the environment to which the system is exposed. The rate of deterioration in the future (the rate of deterioration in Section B in Figure 1) may increase due to service environments in response to global climate change and the increase in services, or may decrease due to the introduction of innovative materials. In addition, severe accidents caused by natural hazards may cause a sudden decrease in performance. Life cycle rates may change over time, as global climate change may affect both the severity and frequency of natural disasters. Structural performance must be maintained within an acceptable range through continuous inspection and monitoring of its life cycle. If the performance level is below a certain threshold, the infrastructure system needs to be rehabilitated or repaired. The minimum level of performance (e.g., goal reliability, serviceability, or resilience to risks and hazards) depends on many factors, including risk tolerance in the industrial engineering community, functional evolution, and changing social expectations and values. After a severe accident, the performance of industrial projects may return to pre-occurrence levels, low or high (the case where performance after recovery is higher than the initial performance is described in Figure 1). Improving performance after improvement depends on existing resources (future economic conditions), technology development, and whether new structural design criteria and codes (related to social needs) have been introduced. Recovery time is very uncertain due to fundamental uncertainties in the system conditions before an event, future resources and technological advances.

Uncertainty exists at all stages of predicting system life cycle performance and increases over time. Thus, the overall quality of life cycle engineering decision-making depends on the evolutionary models of time components of risk (hazards, exposure, and vulnerability) as well as external factors (e.g., social, technology, political, and economic conditions). Approach to Dealing with Related Uncertainties As described in Section 1, conventional decision-making methods correctly demonstrate the degree of inherent uncertainty by assessing advanced potential risk in static conditions, but it is not suitable for dealing with the spread of uncertainty in evolving conditions. For example, under certain circumstances, ambiguities in decision consequences may not be apparent until the initial decision, or, based on current limited knowledge, it is difficult to model a clear pattern of the relationship between life cycle changes and system performance. In addition, interaction, interdependence, and conflict between evolving

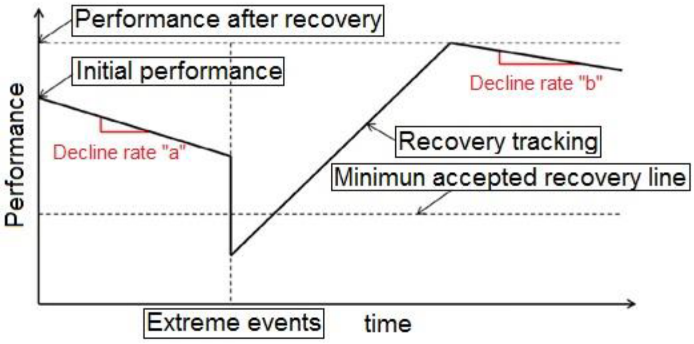

Figure 1: The life cycle performance of an industrial infrastructure system that is subject to changing conditions.

conditions are not currently well understood [20].

One sensible way to address such evolving conditions and reduce communication uncertainty is to facilitate decisions that can be updated by accessing more information or advanced models [21]. By adaptively managing risk, infrastructure systems/communities, and supporting evolving decisions, a flexible and responsive decision-making approach can provide solutions to address fundamental uncertainties and imperfect knowledge at the time of decision-making. Along these lines, a systematic process of adaptive decision making system, along with sequential game updates is introduced in Section 3 and its application is shown in Section 4.

ADAPTIVE DECISION MANAGEMENT SYSTEM AND UPDATING GAME THEORY FOR A SEQUENTIAL DECISION SCENARIO

As discussed in Section 2.2, decision-makers are challenged by inherent uncertainties and an incomplete knowledge base, especially when deciding to change circumstances in industrial projects. In this section, an adaptive decision management system for the underlying industrial engineering systems and communities is presented, and along with game updates, a simple decision scenario is followed. The proposed method of adaptive decision management system allows decision makers to adjust plans and strategies because new information is gathered over time and incorporates a better understanding of risk-conscious decision making.

Adaptive Decision Management System for Industrial Infrastructure Systems and Communities at Risk

In this paper, adaptive decision management for industrial engineering infrastructure systems and communities with the aim of managing industrial waste is proposed to improve understanding of evolving conditions and develop flexible and responsive decision strategies in managing evolving hazards. Provide. At the time of each decision, there is only limited information and knowledge to understand and describe the prediction of change conditions and their impact on the performance of systems and communities. In conventional decision making, life cycle risk is estimated based on prior knowledge in the design and planning stages and may not have the characteristics of an unexpected or highly variable change in risk assessment, ultimately leading to underestimation or Over-assessment of future risks.

To reduce deviations from real risks in the future and to enable more informed decisions responsive to such changes over time, the proposed method of adaptive decision management follows an iterative cycle at each time step (t_1, t_2, ... , t_n), the same As shown in Figure 2. The time frame can be related to the budget cycle for public investment, administrative conditions for the selected official cases or the duration of the responsible decision. After defining the system features and engineering objectives, the initial performance of the system in the first period (t_1,t_2) is estimated using the initial models of the evolving conditions developed based on the existing knowledge at the beginning of the work. Period (t=t_1). Decision making is done through optimization with predefined goals and constraints and is implemented in the first period, while evolving conditions and the effects of decision making on systems and communities. It is observed simultaneously. Conditions with consecutive game updates are used to update evolving condition models at a later time (t= t_2), and decisions are adjusted to reassess risk and better understand their effects on performance of the system. The system features and objectives are set and other constraints (e.g. budget or resources allocated, target reliability for the next time period(t_2, t_3), etc.) can be defined from the beginning at each step. Through sequential processes, the proposed method of adaptive decision management addresses the key issues that should be addressed in decision-making for infrastructure systems and communities in times of change:

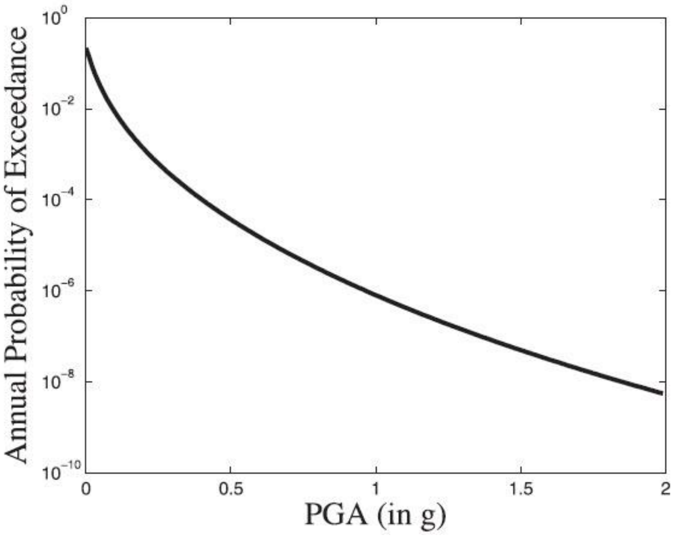

Figure 2: Seismic hazard curve for the site.

- Given the fundamental uncertainties associated with life cycle performance prediction, in response to the variables previously discussed, future performance cannot be accurately predicted, even if reliable information and advanced models are currently available. The proposed adaptive decision management method explicitly recognizes the conditions of change and uses the information gathered to reduce uncertainty on a regular basis to improve understanding.

- One of the goals of the adaptive decision management framework is to ensure that it adapts to future changes. Flexibility in sequencing decisions can improve risk management strategies over time by responding to time-varying factors such as changing economic conditions, technology development and increasing risk, vulnerability exposure and recovery. In addition, in the decision sequence, goals may change over time. Decision-makers' risk-taking attitudes and public perceptions may evolve over time as the risks to infrastructure systems and communities increase. The cycle of repetition of goals with the guidance of time as well as the attitude of evolving risk is included in the proposed adaptive decision management framework.

An important feature of the adaptive decision management framework is the ability to incorporate what is learned into future decisions through explicit mechanisms for linking new information from monitoring to decision making. Different modes or variables are controllable, and based on monitoring results, successive game updates can be used to update existing knowledge about natural modes (or parameters of existing predictive models). In the next section, an update on game theory is introduced and applied to address uncertainty and continue knowledge accumulation.

Game Theory Sequence Update

Game theory is used to update the previous probability P' [θ_i] for a hypothesis when new information is available. The rules of the game express the posterior probabilities as $P''[\theta_i]$ according to Equation (1).

$$P''[\theta_i] = P[\theta_i|z_k] = \frac{P[z_k|\theta_i]P'[\theta_i]}{P[z_k]} \tag{1}$$

According to this relation, θ_i is the real natural state, z_k is the observed state, and $P'[\theta_i]$ is the previous probability. Game updates are especially convenient when the sequence of monitoring time data is used to update knowledge over time. At timet_1, the decision maker calculates an action based on some predefined criteria (maximum profit, minimum cost, maximum tool, etc.) and the results of previous probabilities. In other words, the best performance at $t_1$minimizes the expected loss or, by equivalent, maximizes the projected maximum profit and schedule in all possible cases during the first interval between$t_1$andt_2. Based on this criterion, it is assumed that an alternative has been chosen as the initial decision, but the true state of nature, θ, is unknown at the first distance at this time. At timet_2, even if the true state of nature, θ_3, has occurred, the decision maker is not aware of it, because no monitoring has taken place. Using the same possibilities as before, the decision maker chooses an action to make the decision. The same process is repeated until the final decision. In order to show the consecutive updates of the game based on the monitoring results, a case of high quality monitoring is used for the whole time horizon. As before, the decision is made at time$t_1$based on the previous probability. In the case of the second decision, t_2, new information about the modes is made available and can be combined with the previous probability to perform the new probability. If the state observed in the first step is between $t_1$and $t_2$asz_3, the posterior probability θ_1 is considered as relation (2).

$$P''[\theta_1] = P[\theta_1|z_3] = \frac{P[z_3|\theta_1]P'[\theta_1]}{P[z_3]} = 0.0455 \tag{2}$$

Based on this process, state probabilities are re-evaluated and updated. At timet_2, a decision-making system selects an activity based on previous probabilities,$P''[\theta_1]$. Table 1 shows the posterior probabilities of successive game updates under three monitoring programs. Because low quality monitoring, regardless of the actual situation, assigns the same probability to all cases, but does not update the previous probabilities over time. For medium and high quality monitoring programs, if the results consistently showz_3, the probability θ_3 approaches one, and the probabilities θ_1 and θ_2 become zero as time accumulates knowledge about the modes. In some cases, game updates may not be helpful, especially when the state of nature is not measurable or measurable, or when future changes (which are rare and uncontrollable) are currently unthinkable. In this case, different methods will be needed to deal with the ambiguities.

Table 1: Natural states and their probabilities.

Normal	θ_3	θ_2	θ_1
Presumption	0.2	0.6	0.2

APPLYING THE PROPOSED METHOD ON THE BENCHMARK: INCREASING THE EXPOSURE AND VULNERABILITY OF A SMALL RESIDENTIAL COMMUNITY IN THE NORTH OF TEHRAN FOR INDUSTRIAL WASTE

In one benchmark, a hypothetical residential community in the north of Tehran is considered to demonstrate the application of the proposed method of adaptive decision management to the decision-making problem in relation to industrial waste, the first discussion of which begins with the earthquake. The danger of seismography evolves over time. It is assumed that the residential community is located in the northern suburbs of Tehran and now consists of 1000 buildings. It is assumed that all buildings are located in a relatively close location and experience the same level of ground motion for a given earthquake scenario. Under this assumption, the site-specific seismic hazard curve for this community is based on ten independent seismic sources and is shown in Figure 2.

The seismic hazard for society evolves over a period of 100 years in the city of Tehran, because its vulnerability increases as a result of population growth and incremental structures. First, society expands over time to support population growth by adding more homes, and consequently, community exposure increases over time. In addition, residential buildings in the community gradually expand, over time, vertically or horizontally to support population growth and family expansion. Such informal expansion of the building increases the seismic vulnerability of the buildings and ultimately affects the resilience of the community that supports them. This leads to an increase in waste in a residential or industrial area [1].

It is assumed that 75% of the primary buildings constructed in the hypothetical community are one-story buildings (Mode 1 in Figure 3) and the rest of the buildings are two-story (Mode 2 in Figure 3), which is generally assumed The volume of waste is such that it can be measured for this level. Existing buildings are gradually expanding, while new buildings are being built every year. Again, 75% of newly built buildings are initially in state 1, 25% are in state 2, and then evolve over time. Figure 3 considers the 9 modes of residential buildings constructed of masonry reinforced concrete frames provided by [1] to simulate building expansion sequences and assess seismic hazard change over time. The time-dependent distribution of building states is modeled as a discrete chain of time with a P matrix that describes the transfer probabilities, which is a 9x9 matrix.

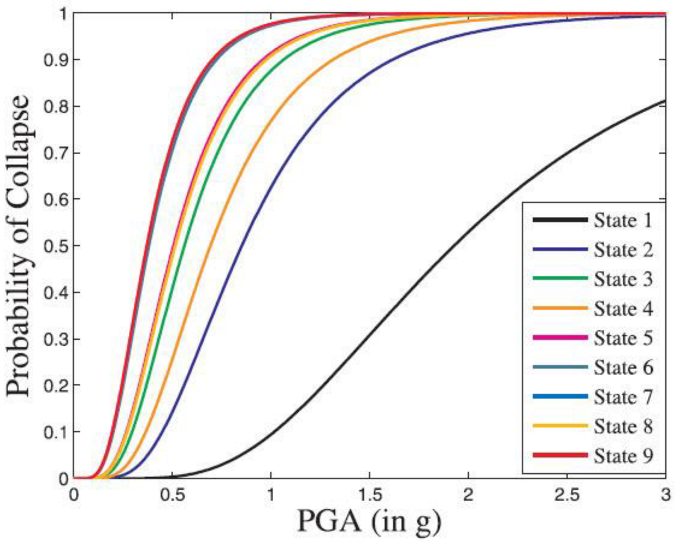

Figure 3: Demolition fragility curve for 9 building modes.

In the decision-making process for simplicity, three scenarios of different population growth rates include slow, medium and fast as the main drivers of the expansion of incremental buildings (increasing vulnerability) as well as the number of new buildings built per year (increasing exposure) Are considered. Estimated population growth rates from the latest edition of the United Nations Global Urban Outlook and related possibilities are summarized in Table 2. The Markov chain transfer probability matrix with the 9x9 matrix is used for modeling. Incremental building expansion is different for each population growth rate scenario and, consequently, the increase in industrial waste: the same transfer probability matrix described in [1] is used for the intermediate scenario, while some elements in the matrix are used. They are adjusted for slow and fast scenarios to fall behind or accelerate the building effectively. Figure 4 shows the distribution of building condition after 50 years under three different population growth scenarios. It should be noted that the population growth rate is assumed to be statistically independent over time.

Comparative decision making process

Local government organizations and policymakers are examples of people responsible for managing the seismic hazards of community buildings. Their decisions should be based on quantitative evidence and a systematic approach that reflects provocative uncertainties that are reflected in the performance of the building life cycle as well as the conditions to which it is exposed. In this study, a decision model is used to evaluate four alternative policies designed to reduce industrial waste and seismic hazards in the presence of waste for industrial projects in addition to alternative options. These four policies include taking no action, prohibiting gradual expansion into vulnerable areas (modes 6, 7, and 9), increasing non-proliferation regulations into five vulnerable areas (modes 5, 6, 7, 8, and 9), and seismic reconstruction. Mandatory for three vulnerable areas and forced seismic reconstruction for the other five vulnerable areas. For policies 2 and 3, new buildings are built in the industrial sector each year to compensate for the number of unauthorized residents due to restrictions on the expansion of industrial buildings. The seismic flexibility required by policies 4 and 5 results in a 60% increase in the mean values of fall fragility curves relative to non-degraded buildings.

Table 2: The scenario of population growth rate and industrial waste growth in an area north of Tehran and the probability assigned to it

	Fast	Medium	Slow
Annual growth rate	6 %	3.5 %	1 %
Presumption	0.2	0.6	0.2

Figure 5 shows the process of the decision management system for the problem ahead. Initially, the intended time, community characteristics (e.g., site-specific seismic hazard curves, initial building state distribution, and fall fragility curves for each building state) and decision objectives and constraints are defined. Based on the available knowledge, the probability distribution of annual population growth rate in the community and the rate of exposure and evolving vulnerability associated with it have been modeled to estimate future building expansion sequences and seismic collapse rate of the community with the aim of improved industrial waste management. . Among the five alternative policies, the policy of minimizing the cost of the projected cumulative failure of the community due to the seismic collapse of buildings is chosen as the initial decision. During the decision interval, population growth rates and government building distributions related to consecutive game updates (introduced in Section 3.2) are monitored and updated for the next decision cycle.

RESULTS

The typical cost of the normal life cycle selects an action among the existing alternative policies that minimizes the expected cumulative failure cost over the intended time for industrial projects. A decision is made at the beginning of the time horizon of industrial projects and is not expected to change. For this reason, the future population growth rate for the next 50 years, which is very uncertain at the time

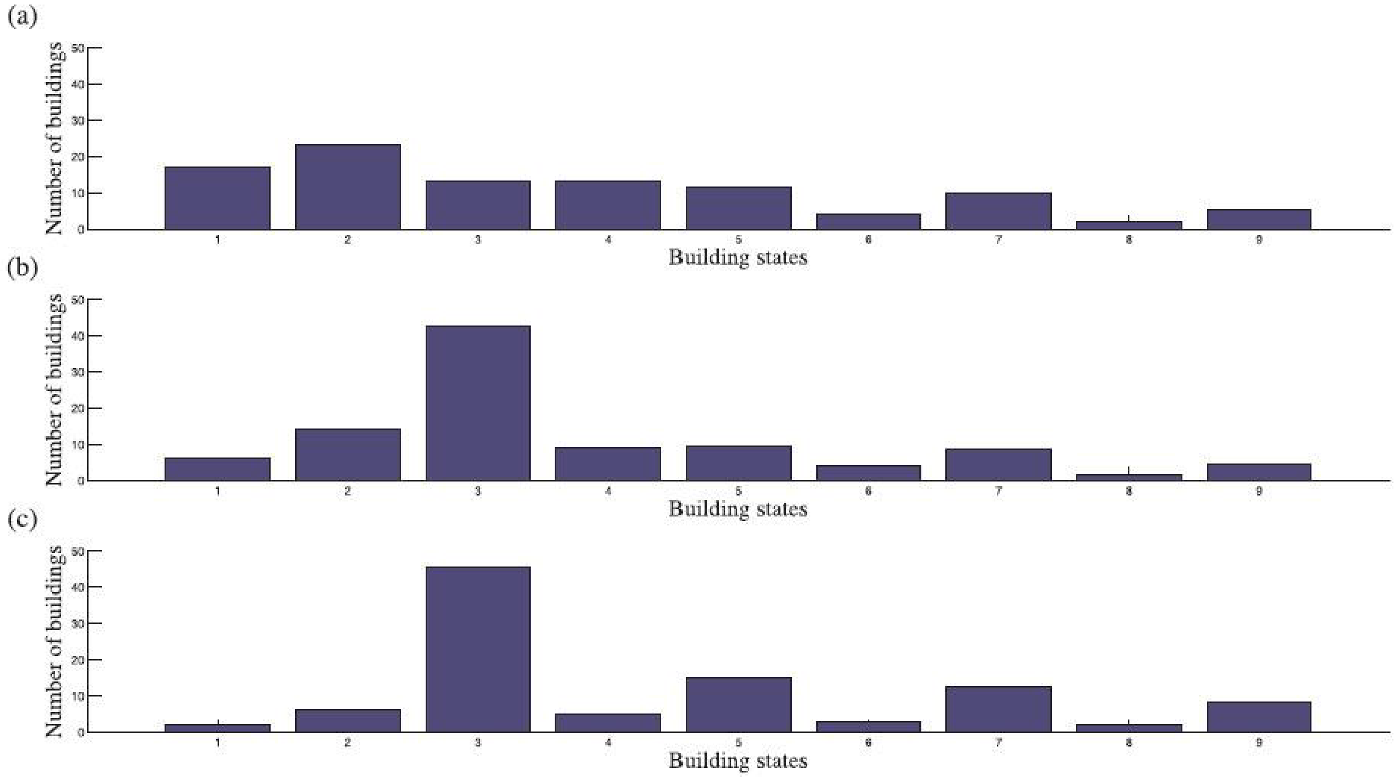

Figure 4: Distribution of modes for buildings after 100 years under three different population growth scenarios: a) slow scenario, b) medium scenario, c) fast scenario.

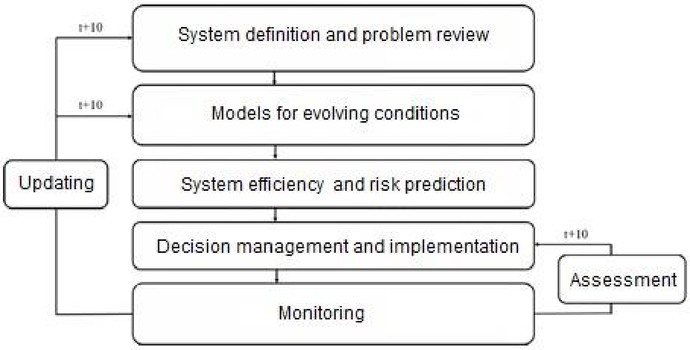

Figure 5: The process of adaptive decision making system for industrial projects.

Table 3: The costs of cumulative community failure under different scenarios of population growth rate and industrial waste: no decision change.

	Fast	Medium	Slow
First mode	3.52	2.18	1.88
Second mode	2.06	1.26	1.05
Third mode	1.81	1.10	0.90
Fourth mode	2.04	1.25	1.07
Fifth mode	1.79	1.10	0.94

of the decision, must be estimated. Table 3 presents the costs of predicting the cumulative failure of the community resulting from the initial decision under different scenarios of population growth and, of course, the growth of industrial waste. If the true state of nature for the next 50 years is slow population growth, alternative policy 3 will lead to the lowest cost of cumulative failure expected by society. Policy 5 is the optimal choice for the rapid population growth rate scenario, while finding the best policy in the medium growth rate scenario is difficult. However, the difference between the projected cumulative failure costs resulting from policies 3 and 5 is negligible due to the fundamental uncertainties embedded in the associated evolving conditions in society. Therefore, non-adaptive decision-making based on current knowledge would be irrational for a 50-year period given the future scenarios.

The use of the Tehran North Benchmark evaluates the advantages of the proposed adaptive decision management framework based on the rate of industrial waste falls and the cost of cumulative community failure compared to conventional decision making. Of course, it should be noted that comparative decision management requires additional costs and constraints such as cost monitoring, operating costs, administrative costs and constraints, and so on. Thus, the total cost of adaptive decision management includes the costs of cumulative failure, the costs associated with switching from one policy to another, and the effort to monitor. However, the benefits of adaptive decision management are not measured solely on the basis of total cost, as the total accumulated cost is converted into an equivalent current value. Through an iterative process, adaptive decision management allows decision makers (at any point in the decision) to evaluate alternative policies based on the profit and cost that occurs only during their decision-making period and from their own perspective. Make the most of it. In other words, the results of adaptive decision management are the set of best actions for each decision maker over the time axis. The sequence of actions obtained from such a process may not be the best sequence from the perspective of the current decision maker (estimated at current value), but it can have maximum benefits for current and future decision makers. The rate of seismic collapse (defined as the ratio of the number of collapsed buildings to the total number of community buildings) and the estimated cumulative failure cost of the community under two population growth rate sequences after applying comparative decision management can be seen in Table 4, witnessed. In fact, a general comparison with the comparative decision management method presented in [22] has been done in this section, which the results of this research in terms of sequence A and B as well as *E*[C_f] which is the total cost of damages. it shows.

Table 4: Industrial waste reduction rate.

	E[C_f]	Sequence B	*E*[C_f]	Sequence A
		Collapse rate		Collapse rate
Conventional mode	1.088 $ M	5.91E-05	1.815 $ M	4.9971E-05
Adaptive mode presented in [22]	0.952 $ M	5.29E-05	1.796 $ M	4.8578E-05
The comparative mode presented in this research	0.847 $ M	5.14E-05	1.745 $ M	4.8572E-05

CONCLUSION

Systems and societies face the fundamental challenges of increasing risks and the uncertainties of dynamic changes in social, economic, political, technological, and environmental conditions. Risk assessments and decisions about industrial infrastructure are often implicitly based on the assumption that the underlying environments in which they are located are dynamically stable over the life of their service and may therefore be Uncontrolled. In addition, the growing awareness of research trends and practical interests in industrial infrastructure has raised more concerns about adapting to future changes and potential challenges. However, due to incomplete knowledge and incomplete modeling at the time of writing, the ability to predict changes in the factors governing industrial infrastructure systems is inherently limited over their lifetime. The adaptive decision management system arises from a need for decision-making methods that provide flexibility for future decision-makers to solve problems when accessing more information or modeling. This paper addresses these concerns by proposing an adaptive decision management system for industrial engineering equipment and communities exposed to evolving conditions with the aim of improving industrial waste management. The proposed adaptive decision management system framework provides an evolving iterative cycle aimed at continuously improving decisions by learning from monitoring or testing results and reducing the vulnerability of the system and society to evolving risks. Through this process, the framework of the adaptive decision management system can explicitly detect and use changes in future situations and adjust decisions over time. To better understand how to implement the proposed method of adaptive decision management system in reducing industrial infrastructure risk, this paper presents a hypothetical decision problem for a small residential community in the north of Tehran that is exposed to industrial waste hazards. It was assumed that society has been exposed to change and vulnerability over a period of 100 years. At each decision stage, the characteristics of the community and the conditions of change are recorded using a series of game updates, and previous decisions are re-evaluated and adjusted based on new knowledge. Optimal decision sequence leads to a reduction in the rate of seismic fall and retention of industrial waste at the level and costs of cumulative failure of society compared to conventional approaches and proper management of industrial waste. The overall risk reduction is more significant when society is exposed to dynamic change. In this particular decision-making issue, when considering the additional costs associated with adaptive decision-making practices, the decision sequence does not appear to be making a good profit in terms of the current discount value. However, the adaptive decision management system allows future decision makers to use up-to-date knowledge and modeling improvements to minimize the benefits or minimize the estimated costs of making their own decisions. In this context, the effectiveness of the adaptive decision management system should not be measured by estimating the conventional cost at which subsequent benefits and costs are reduced for present value. The proposed method of adaptive decision management system facilitates effective risk management in transformation conditions and strengthens the implementation of industrial waste resilience practices over time. Adaptive decision management system approach may take advantage of other types of infrastructure systems / industrial infrastructure communities in their upgrades and flexibility, especially when exposed to evolving conditions. In addition, while the framework of the adaptive decision management system is based on a changing urban environment (where community exposure and vulnerability increase due to population growth), the wide application of the ratio It has other evolving conditions, such as changes in social and political needs and other preferences, such as technological advances, global climate change, and changing economic conditions.

REFERENCES

1. www.fao.org/save-food/resources/en/
2. www.lovefoodhatewaste.com/
3. Bond M, Meacham T, Bhunnoo R, Benton T. Food waste within global food systems. Swindon, UK: Global Food Security; 2013.
4. WRAP. Estimates of food and packaging waste in the UK grocery retail and hospitality supply chain. 2015.
5. Whitehead P, Parfitt J, Bojczuk K, James K. Estimates of waste in the food and drink supply chain. Banbury: Waste and Resources Action Programme. 2013.
6. Bräutigam KR, Jörissen J, Priefer C. The extent of food waste generation across EU-27: Different calculation methods and the reliability of their results. Waste Manag Res. 2014;32(8):683-694.
7. FUSIONS E. Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression. 2016.
8. Chang NB, Pires A, Martinho G. Empowering systems analysis for solid waste management: challenges, trends, and perspectives. Crit Rev Env Sci Tec. 2011;41(16):1449-1530.
9. Harrison KW, Dumas RD, Solano E, Barlaz MA, Brill Jr ED, Ranjithan SR. Decision support tool for life-cycle-based solid waste management. J Comput Civ. 2001;15(1):44-58.
10. Costi P, Minciardi R, Robba M, Rovatti M, Sacile R. An environmentally sustainable decision model for urban solid waste management. Waste Manage. 2004;24(3):277-95.
11. Den Boer J, Den Boer E, Jager J. LCA-IWM: a decision support tool for sustainability assessment of waste management systems. Waste Manage. 2007;27(8):1032-45.
12. Karmperis AC, Aravossis K, Tatsiopoulos IP, Sotirchos A. Decision support models for solid waste management: Review and game-theoretic approaches. Waste Manage. 2013;33(5):1290-301.
13. Soltani A, Sadiq R, Hewage K. Selecting sustainable waste-to-energy technologies for municipal solid waste treatment: a game theory approach for group decision-making. J Clean Prod. 2016;113:388-99.
14. Wang S, Huang GH, Yang BT. An interval-valued fuzzy-stochastic programming approach and its application to municipal solid waste management. Environ Model Softw. 2012;29(1):24-36.
15. Rojo G, Glaus M, Hausler R, Laforest V, Bourgeois J. Dynamic waste management (DWM): Towards an evolutionary decision-making approach. Waste Manage Res. 2013;31(12):1285-92.
16. Solomon S, Qin D, Manning M, Chen Z, MarquisM, et al. Contribution of working group I to the 4th assessment report of the intergovernmental panel on climate change. 2007.
17. Bastidas-Arteaga E, Schoefs F, Stewart MG, Wang X. Influence of global warming on durability of corroding RC structures: A probabilistic approach. Eng Struct. 2013;51:259-66.
18. Lounis Z, McAllister TP. Risk-based decision making for sustainable and resilient infrastructure systems. J Struct Eng. 2016;142(9):F4016005.
19. Portera KA. Safe Enough? A Building Code to Protect Our Cities as Well as Our Lives.
20. Lee JY, Ellingwood BR. Ethical discounting for civil infrastructure decisions extending over multiple generations. Struct Saf. 2015;57:43-52.
21. Olsen JR, editor. Adapting infrastructure and civil engineering practice to a changing climate. American Society of Civil Engineers.
22. Lee JY, Burton HV, Lallemant D. Adaptive decision-making for civil infrastructure systems and communities exposed to evolving risks. Struct Saf. 2018;75:1-2.