# FUTURE STUDY OF FIRE DISASTER RISK IN IRAN USING A SCENARIO PLANNING APPROACH

## *INCENDIES CATASTROPHIQUES DU FUTUR EN IRAN: UNE APPROCHE SCÉNARISTIQUE*

Jafari H.,[1] Sheikhbardsiri H.,[2] Mohammadi M.[3]✉

[1]Health, Work and Environment Research Center, Sirjan School of Medical Sciences, Kerman, Iran
[2]Disasters and Emergencies Management Center, Kerman University of Medical Sciences, Kerman, Iran
[3]Centre for Environment and Population Health, Griffith University, Australia

**SUMMARY.** Fire disasters are one of the most common technological disasters in Iran. These disasters have killed many people and resulted in significant economic loss. The "Plasco" building fire in 2017 is one example of these catastrophic disasters, when most of Iran was affected by its tragic news. Regarding the increasing number of risk factors for fire disasters, we aimed to study future scenarios for such disasters in the country. The present study is a futuristic study with an exploratory approach that uses an intuitive logic scenario development approach. We used document analysis, semi-structured interviews, and the Delphi technique to identify driving forces and develop scenario stories, and finally those scenario stories were validated. In the document analysis phase, 22 documents were identified and analysed. After collecting information related to documents and analysing ten interviews, 41 of the driving forces were identified. By drawing the scenario matrix, four alternative scenarios for the future of fire disasters were developed. Two dimensions for scenario development were the correct application of fire prevention laws and access to driving technologies. Policymakers can concentrate on these key factors for best planning in the mitigation of fire disasters. In addition, studying scenarios can help managers and officials to better develop strategic plans for disaster risk reduction.

**Keywords:** scenario planning, future, fire disasters, technological disasters

***RÉSUMÉ.*** *Les incendies catastrophiques sont les désastres technologiques les plus fréquents en Iran. Ils y ont tué de nombreuses personnes et entraîné des pertes économiques significatives. L'incendie du Plasco, en 2017, est un exemple de ce type de catastrophe, qui a affecté la plupart des iraniens. Eût égard à l'augmentation des facteurs de risque, nous avons étudié les scenarii possibles de ce type d'accident en Iran. Il s'agit d'une prospective, explorant divers déroulements considérés comme possibles. Nous avons utilisé les données de la littérature, des entretiens semi- structurés et un consensus selon la méthode Delphi pour identifier les circonstances de survenue et écrire des scenarii, ensuite validés. L'analyse bibliographique a concerné 22 documents, 10 entretiens ont été utilisés, pour identifier 41 phénomènes déclenchants et écrire 4 scenarii. L'application des lois de prévention des incendies et la limitation des facteurs favorisants, sur lesquels le législateur devrait se pencher. Ces scenarii peuvent permettre aux responsables, à leurs niveaux, de développer des plans de prévention des catastrophes liées aux incendies.*

***Mots-clés :*** *incendie, catastrophe technologique, modélisation, prévention*

✉ Corresponding author: Mahan Mohammadi, Public Health Ph.D. Student, School of Medicine, Centre for Environment and Population Health, Griffith University, Australia.
Email: Mahan2mo@gmail.com
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## Introduction

The dramatic increase in the number of vehicles in the last few decades has led to the emergence of new problems, and unfortunately, operations-based reliance planning has poorly met disaster management and risk reduction needs. The heavy shadow of uncertainties and one-off disasters has changed the situation in such a way that it is difficult to predict the future of this changing world.[1] Failure to accurately predict the future, as well as the complexities caused by increasing technological changes, has led researchers to take advantage of future studies. The methodology of future study is now implemented in planning, scientific prediction, and technological developments related to accidents.[2]

In the year 2016, 327 disasters were reported across the world, of which 136 were technological. These technological disasters cost the world more than USD 8 billion. The most common technological disasters this year have been fires and explosions, vehicle accidents (road, air and sea), terrorist attacks, and social conflicts.[3] Similarly, in recent decades, Iran has been facing a variety of technological disasters, including multiple plane crashes, and numerous road and rail traffic accidents with extensive damages.[4]

The most important technological hazards in the country are fires in residential, commercial and industrial buildings. The 2017 collapse of the 17-storey, high-rise, landmark building in Tehran (capital of Iran) is one of these examples. In this disaster, 22 people died, at least 70 were injured, and the cost of damage to commercial units inside the complex totalled 500 million US Dollars. The building collapse led to the unemployment of more than 3,000 people.[5]

Although many measures have been implemented to mitigate technological disasters at the level of various authorities, based on the rising number of these disasters, however, it can be concluded that the measures are not based on future thinking followed by a systematic orientation. Along with technology development, future research studies are needed to identify the root causes of these technological disasters.[6,7]

Achieving an acceptable level of disaster preparedness at the time when our constantly changing world is facing the advent of new technologies, patterns of vulnerability, risk-taking and capacity-building are affected by many uncertainties. In the future, fire disasters need to be investigated by future study researchers to reduce the risk of these accidents.

So far, no study has been conducted to develop future scenarios of technological disasters in Iran. Studies on disaster management and technological disasters have rarely provided a futuristic perspective.[8,9] Bagheri Lankarani studied the trend of traffic accidents countrywide as well as the volume of car manufacturing. In a comprehensive study, Ardalan et al., in their future study, examined the factors influencing disaster risk reduction by focusing on natural disasters.[10] Future research activities that aim to influence the macro policies of a country or organisation are generally carried out with a scenario approach.[11] Scenarios are pictures of possible futures that serve to formulate strategies by systematically discovering the challenges and opportunities ahead. This method has a simple way of publishing results and can be more effective in uncertain situations.[12] Scenario writing is not a prediction of the future, and this method is suitable for decisions that have a long-term effect. Scenarios are good starting points for changing organisational strategies.[13]

In this study, we intended to identify the key factors influencing the occurrence of fire incidents, formulate future scenarios considering these accidents, and finally draw the alternative futures for each hazard. Developing future scenarios by using the driving forces will enable policymakers to gain a better understanding of factors that can scale down the number of accidents and find out the relationship between them, as well as root cause analysis of incident formation. In addition, it will ease the prediction of different policy impacts. Therefore, considering the importance of future studies, especially scenario writing in fire response policy-making, the significant number of deaths related to these incidents in Iran, and the empty place of a systematic and comprehensive approach to manage and mitigate fire incidents, the present study was designed as an intuitive logic scenario planning methodology over a 15-year horizon. It is hoped that the results will pave the way for more effective management and response to fire accidents, along with technology developments in the upcoming decades. In ad-

dition, the developed scenarios can determine the decisions' results for managers and policymakers in the future.

## Method

The present study is a futuristic study with an exploratory approach that uses an intuitive logic scenario development approach. Therefore, in terms of purpose, this research is exploratory, and in terms of process design, it is a combination of quantitative and qualitative studies. Scenario development in this research has been performed in three stages, including identification of the driving forces, uncertainty identification, and scenario mapping. In order to identify the drivers, a two-step document analysis, key factor identification, and their future status were done using the experts' point of view. First, documents related to reducing fire accidents were identified and analysed. In the document analysis phase, 22 documents were identified and analysed. In the second phase, ten Iranian experts in the field of mitigating and managing fire disasters were interviewed. The data obtained from this step were analysed using the STEEP analytical framework. After collecting information from documents and analysing interviews, a list of the driving forces was extracted.

This list was distributed among 30 experts in the form of a researcher-made questionnaire, based on two criteria of uncertainty and importance. For this purpose, three steps of driving force prioritisation, extraction of key uncertainties, and discovering scenario dimensions were implemented. These 30 professionals had at least three years of experience in mitigating and managing fire accidents.

In the analysis phase, the average score of each factor was calculated by the latest version of SPSS software. Based on these scores, the effectiveness and uncertainty of factors were judged. After receiving the questionnaires, the ranked factors were replaced based on the score they obtained in a matrix, with the degree of uncertainty on one axis and the degree of importance on the other. The fourth dimension of scenarios was identified by the scenario matrix.

In the last step, the story of scenarios was written using dimensions of the scenario and drawing the causal relations, and a standard questionnaire was used to determine scenario validity.

*Scenario development in intuitive logics*

In this methodology, driving forces were identified by several methods and then these driving forces were analysed with a key uncertainty matrix (*Fig. 1*). After placing the factors, the matrix space was divided into four quarters and the factors were divided into four groups as follows.

1 High Importance – Low Uncertainty
2 Low Importance – Low Uncertainty
3 Low Importance – High Uncertainty
4 High Importance – High Uncertainty

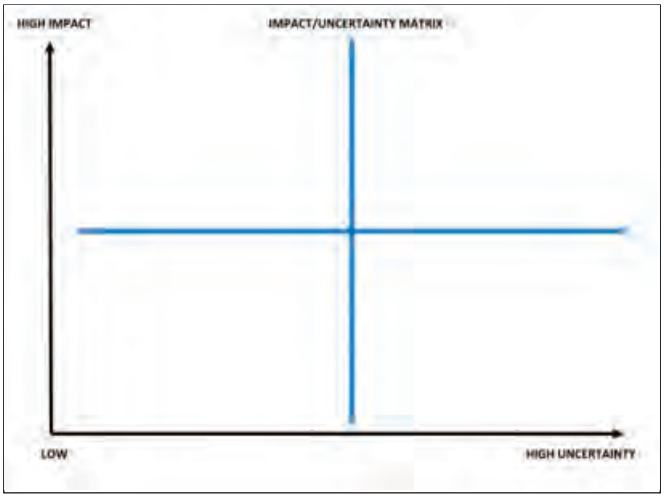


**Fig. 1** - Key uncertainties matrix

Components that were exposed to high importance and high uncertainty in the area identify as critical uncertainty factors.[14] These are issues that could potentially lead to strategic changes in the hypotheses, and the results for these are very uncertain. The factors that locate in this space are used to construct the logic of the scenarios.

Then the dimensions of the scenarios are identified by selecting two critical uncertainties and plotting them in a matrix (*Fig. 2*). Key uncertainties are factors that have both high uncertainty and high importance. Two factors with high uncertainty were used for scenario building. Finally, by combining two critical uncertainties, the final form of the four scenarios appeared.

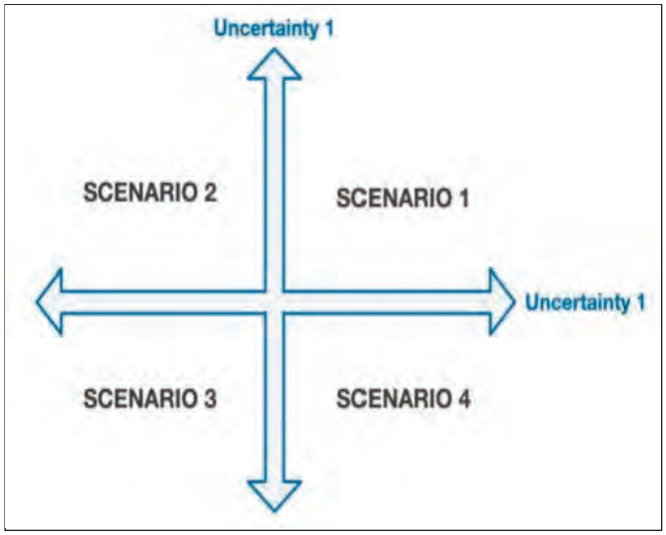


**Fig. 2** - Scenario Matrix[15]

## Results

After analysing the data of documents and interviews, 41 driving forces were identified, including seven social factors (level of literacy in the country, public attitudes toward safety, how populated the country is, size of cities, level of public awareness, and commitment to safety education), three factors in the political category (Western countries' sanctions on Iran, integrated management of fire disasters, and risk perception in decisionmakers), six factors in the economic category (Western countries' sanctions on Iran, annual inflation rate, budget allocation of fire departments, exchange rate, economic situation of the people, and GDP), 10 factors in the technology category (technology development alternatives for fire mitigation in buildings, penetration rate of using boilers as a source of heat, development of robotic technology in firefighting, increased level of city gas consumption in the country, commitment to use fire retardant materials in constructions, access to new technologies in firefighting, access to new fire detection technologies, diversification of energy use in the community, and installation of lightning arrester in buildings), one factor in the environmental category (climate change), and 14 factors in the infrastructure category (the rate of urbanization, increasing the capacity of the fire department, compliance with electrical safety standards in building constructions, degree of compliance with city gas standards, integration of fire prevention laws, proper implementation of fire prevention laws, plan improvements for evacuation of large buildings, increased coordination among fire prevention authorities, obligatory installation of firefighting equipment in all buildings including residential ones, more attention of policy makers to fire prevention, paying attention to safety criteria in buildings, volume of renovation of worn-out structures, amount of road traffic in cities, and developing a comprehensive system for collecting data on fire incidents).

In the next step, the following five uncertainties were identified as key uncertainties: access to new technologies in firefighting, development of central boiling water systems, development of alternative fire technologies in buildings, comprehensive fire prevention laws, and proper implementation of these laws.

Then, by combining the key uncertainties, dimensions of the scenario were identified. Dimensions of the scenario are shown in *Table I*.

Finally, the scenario matrix was drawn (*Fig. 3*).

**Table I** - Dimensions of the fire incident scenario

| Scenario dimensions | The name of the dimension | Driving forces with high uncertainty and high impact potential |
|---|---|---|
| The first dimension | Access to driving technologies | Access to new technologies in firefighting<br>Development of central boiling water systems<br>Development of alternative fire technologies in buildings |
| The second dimension | Correct application of fire prevention laws | Comprehensive fire prevention laws<br>Proper implementation of fire prevention laws |

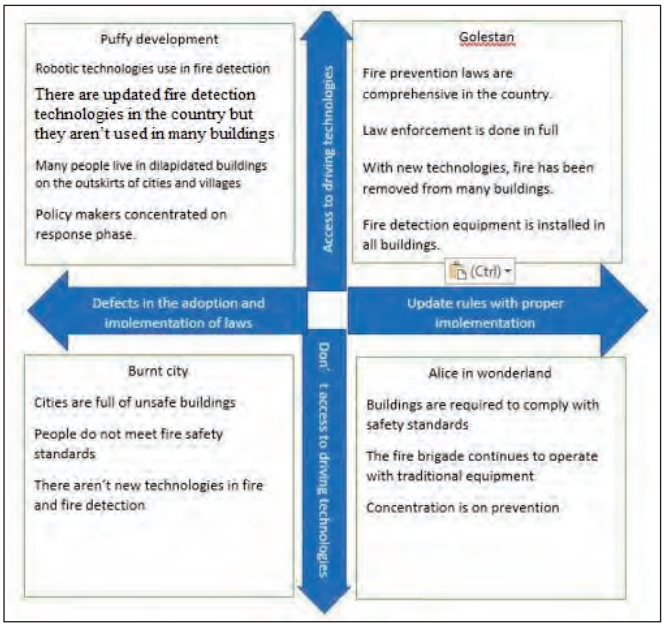


**Fig. 3** - Fire disasters scenario matrix

## Scenario stories

*Scenario # One: Golestan (name of a big and beautiful garden in Iran)*

The "Golestan" scenario is a normative and optimal scenario. In this scenario, we live in safe and highly developed cities; buildings are generally made of fireproof materials, and fire detection equipment is available in all constructions. Most buildings have central boiling water systems, so the naked flame is removed from these buildings. The country has experienced economic growth, and inflation has been minimised so that people can afford safety equipment easily. In the imaginary cities of this scenario, comprehensive and up-to-date rules and regulations prevail. The importance of legislation and its implementation is clear to policymakers, managers and the public. "Golestan" is safe for preschool children because they have learned the basics of fire safety since an early age. In school curriculums, the "Safe Behaviour" course is designed to teach students about principles of safety and safe behaviours in order to prevent many different types of incidents. In the mass media, there is educational content to promote a cultural tendency to comply with construction standards. In 2034, the fire department will be equipped with the newest equipment to be able to provide a prompt response in all types of incidents. New vehicles such as vertical flight helicopters will solve the traffic problem for this organisation. Robots that overcome human limitations are widely used to extinguish fires and rescue victims.

*Scenario # Two: Puffy Development*

The "Puffy Development" scenario is an exploratory scenario in which an unbalanced development has occurred in the country. In this scenario, the economic and political situation of the country has improved and infrastructures for the introduction of new technologies in the field of fire safety and response are developed. Firefighters are equipped with robotic technology as well as advanced ambulances. New and safe construction materials are available and people can afford to buy and use them. But this is only one side of the 2034 Iran story. On the other side, we are dealing with flawed laws that are not being enforced properly. In this scenario, the society is full of risky behaviours. These behaviours manifest themselves in the form of poor compliance with the standards. Undoubtedly, along with the shortcomings of our laws, we have also had shortcomings in education. During these years, a coherent and effective educational program in society, especially in schools, has not been implemented and because of that, our people will lack the safety culture. In this scenario, fires continue to occur regularly, and traces of human error can be detected in all incidents.

*Scenario # Three: Alice in Wonderland*

The "Alice in Wonderland" scenario is an exploratory scenario. The economic, political and social trends of this scenario predict it as a more probable scenario because this land has always been a land of wonders. This time, the same as the previous scenario, the country is facing an unbalanced development on the horizon of 2034. A coherent and effective education system in schools, universities and mass media has empowered people with high safety culture. The focus of policymakers has been more on prevention and comprehensive laws have been developed to prevent fires. Corruption has also decreased in the country and the laws are being enforced properly. These have provided the basis for reducing fires, but inflation and economic problems, along with political sanctions, made it nearly impossible to introduce new and effective technologies. In this scenario, it is assumed that Iran is in trouble with political issues and that economic and political sanctions have challenged the country's economy. The economic growth rate is negative, and inflation and unemployment rates are higher than usual. The technology-leading companies are banned from doing business with Iran, and this has made it a technologically backward country. The fire department, although perhaps strengthened in human resources, continues to work with traditional equipment. The traditional response is slow despite the metropolitan traffic, and it is a big concern for the organizations responsible for firefighting.

*Scenario # Four: Burnt City*

The "Burnt City" scenario is an exploratory and the most pessimistic scenario. In this scenario, the situation goes backward from bad to worse. Eco-

nomic problems and sanctions prevent access to fire mitigation technologies for the country. The very bad economic situation has led people to show no interest in following the fire safety principles in their constructions. The city is surrounded by unsafe and dilapidated buildings. Occasionally, an accident as large as the collapse of the "Plasco" building affects the country. Bribery and extensive corruption cause law enforcement to be flawed. The imaginary cities of the country in 2034 will remain like a burnt city with insecurity across them. In such situations, high-risk behaviours are abundantly visible among the people and cause too many incidents. Safety education in schools has been forgotten. No organisation is responsible for mitigating the fire accident risks in the country. All organizations shirk responsibility and shift blame to other organizations in the catastrophic events (*Table II*).

**Table II** - Final scores of scenarios validation separately for each scenario

| Evaluation criteria | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| Credibility | 6.15 | 8.5 | 8.05 | 7 |
| Challenging | 6.26 | 7.13 | 7.26 | 6.66 |
| Internal compatibility | 5.35 | 6.25 | 6.05 | 5.05 |
| Relativeness | 6.26 | 7 | 6.53 | 6.43 |
| Design process | 8.45 | 6.7 | 6.65 | 7.4 |
| Total | **6.49** | **7.11** | **6.90** | **6.5** |
| Acceptable score | 5< | 5< | 5< | 5< |

## Discussion

In the present study, using the intuitive logic approach, four scenarios - Golestan, Puffy Development, Alice in Wonderland and Burnt City - were developed in two dimensions of access to fire-extinguishing systems technologies and correct implementation of fire prevention laws for the future of fire accidents. The optimal scenario in this study is the "Golestan" scenario. In this scenario, the country has access to new technologies, the safety criteria of constructions have been improved, and use of technology has led to a faster response to accidents. On the other hand, preventive laws have been fully developed to mitigate the fire risk, and with reduction of corruption in the country, these laws will be implemented properly.[16]

To achieve the best level of fire prevention and control, there must be an effective management system with functionally defined components. It is necessary to define and design a fire safety system on fire prevention management in industrial or urban sectors to help us to predict the requirements in facilities, equipment and human resources. The fire safety system needs to achieve a level of safety that can detect the occurrence of fire in the early stages and take timely action to control it.[17] To achieve these goals, it is necessary to designate specific centres for concentration of facilities and fire control command in each commercial, industrial complex or city.[18] One important matter that should not be neglected is the fire risk assessment. Although fire detection and the extinguishing systems can control numerous fires and reduce damages, in the science of disaster management, priority is given to prevention. Fire risk assessment helps safety personnel to identify hazard in time and take the necessary technical and managerial measures to minimise the possibility of fire.[19] Today, due to expansion of industries and increased complexity in industrial operations on the one hand, and inevitable use of flammable chemicals and heating processes on the other hand, many scientific considerations have emerged in this field. In the past, humans have always sought to reduce the effects of a catastrophe, but today it must be prevented by reducing the risk of fire incidents and controlling them. Nowadays, fire hazard can be identified and controlled implementing appropriate techniques.[20]

Evidence of the shortcomings of applicable laws, equipment, professional training in safety-related organisations, and shortcomings of standards, indicate that some of the safety standards should be revised.[21] Extensive accidents, such as the "Plasco", will not occur.

All conducted interviews, group discussions, surveys, and document analysis show that there is no or very little place for safety in Iranian citizens' mindsets, attitudes, and on their list of priorities, which leads to ignorance of safety principles in their personal and professional life. Safety is neglected in the most fundamental layers of citizens' attitudes in the sense that there is no sign of it in their behaviours.

The interaction between neglected safety in mindset, with legal, technical and engineering shortcomings, insurance regulations and organizational policies, creates a synergistic effect.[22]

A person without a safety compatible mindset, even though working at the heart of a safety-friendly organization, will act as a barrier and weaken the ex-

isting safety capacities in this organization. In the same way, being surrounded by a structure where safety importance is completely neglected inevitably disturbs other members' attitudes toward safety awareness, and it can be transferred from one generation to another. This is how the Iranian community is moving far away from the safety culture.

The educational system (schools and universities), mass media, print media, public relations departments of organizations related to safety matters, the national organization of disaster management and other players should establish agendas to raise public awareness and sensitivity to safety aspects.[23]

A set of measures should be considered to pave the way for a gradual change in mindset and prioritisation of safety requirements in the public mind, complemented by structural and institutional reform. Advancing this pathway requires action research that uses policymaking knowledge to create irreversible and correct pathways to structural and action-based safety reforms.

## Conclusion

In this study, we developed four scenarios using a combination of environmental monitoring methods, document analysis, scenario planning and the Delphi technique with regard to fire incidents. These scenarios can, as a strategic document, influence policymakers' and managers' point of view and provide the basis for purposeful and effective decision making because the purpose of scenario planning is to chart alternative futures. In regards to fire incidents, four scenarios were developed using two dimensions of access to technology and fire prevention laws and regulations. Here, the "Golestan" scenario is considered as a favourable scenario, in which there is access to new technologies and preventive laws, and regulations for fires incidents have been reviewed and implemented correctly. Sanctions, economic indicators, revision of current laws, a reduction in corruption, and efforts to use fire detection and extinguishing technologies in buildings should be considered here.

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