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TRANSPORTATION OF HAZARDOUS MATERIALS IN IRAN: A STRATEGIC APPROACH FOR DECREASING ACCIDENTS

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Abstract. "Hazardous materials" refer to those substances that seriously endanger human lives and/or the environment. The transportation of these materials will be inevitable in the increasingly industrialized economy of Iran. Nonetheless, numerous deadly accidents caused by the movement of these materials necessitate the design and implementation of preventive plans on several levels. This article looks into the present condition of transportation of hazardous materials in Iran and the resulting accidents. Optimal condition for the general transportation system of hazardous materials is delineated with due focus on transportation risk as the main parameter. Strategies for reaching the optimal condition are laid out and the impacts of these strategies on the reduction of accidents are analyzed.

Keywords: hazardous materials, SWOT, strategy, Iran.

1. Introduction

"Hazardous materials" refer to those substances that seriously endanger human lives and/or the environment. These materials are usually grouped into 9 categories, which include gases, flammable liquids, flammable non-liquids, oxidants, explosives, acidic materials, poisonous and contaminated materials, radioactive substances, and other hazardous materials.

Iran's social environment is becoming increasingly exposed to these materials and their transportation: on the one hand, the growth rate of industry is higher than of the other sectors; on the other hand, Iran is an oil-producing country and its oil and gas resources must be transported for domestic consumption and export purposes. Meanwhile, Iran is situated on the transit route of several Central Asian states, most of which produce oil. Increase in the number of automobiles and chronic shortage of adequate roads and railroads has intensified this problem. In addition, the process of de-industrialization in industrial countries leads to the transfer of hazardous industries to countries such as Iran.

Therefore the transportation of hazardous materials will be inevitable in the increasingly industrialized economy of Iran. Refineries, power plants, chemical industries and petrochemicals, recycling centres, power distribution centres, and large cities are the origins and destinations of these materials. Hazardous materials are continuously moved between these centres. These movements are naturally dangerous as the release of hazardous substances as a result of an accident can lead to deaths and irreparable damages to the environment. Therefore, such risks must be minimized to the extent possible.

There are numerous methods for decreasing the transportation risks of hazardous materials. Planners and policymakers have long considered a plethora of these methods and planned accordingly. Nonetheless, transportation of hazardous materials still remains a high-risk endeavor. Within a decade, from 1995 to 2004, there were 116 deaths and 3059 injuries associated with the land transportation of hazardous materials in the US alone. Though official statistics on transportation accidents related to hazardous materials do not exist in Iran, reference to news broadcasts or published incidents can clearly shed light on the seriousness of the situation. A search in the archives of Iran and Hamshahri newspapers showed that in the two months of September and October 1999, 6 accidents took place, the most critical of which led to 20 fatalities and 110 injuries. Incidents such as the drowning of a truck loaded with poisonous materials in a lake behind a water dam, explosion of a fuel tank, and eruption of acid from a truck were reported. The most serious accident took place in 2004. On March 20th of that year, a train loaded with explosives collided with wagons filled with flammable materials at a station in eastern Iran, leading to the death of 283 passengers. In another accident on June 25, 2005 a trailer loaded with fuel hit a number of cars at a checkpoint in south-east Iran leading to 90 deaths and 114 injuries (a detailed overview of these incidents will follow).

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A comparative look at the Iran-US statistics over one year (i.e., 2004) reveals that the death toll in Iran was several times higher than in the States. This is while the US's transportation network is several times larger than that of Iran. The comparison clarifies the gap between the safety level of hazardous materials' transportation system in Iran and the optimal level.

Review and planning can be envisaged on several planes: on the level of a transportation firm, on an industry level (i.e., oil industry), and on the national level (i.e., rail transportation system and road networks).

This article focuses on planning on the national level by drawing on a strategic planning perspective. The aim would be to adopt a preventive outlook when dealing with the transportation of hazardous materials, leading to a "clean" transportation system.

2. Research methodology

The subject of HAZMAT transportation and resulting incidents have been studied in many papers and researches using different approaches.

Some of these papers have studied methods of risk estimation for HAZMAT transportation. For example:

- Leonelli, Bonvicini and Spadoni (2000) introduce a new methodology based on risk analysis for the selection of the best route for the transport of a hazardous substance.
- By Pet-Armacost, Sepulveda and Sakude (1999) a Monte Carlo sensitivity analysis of the unknown parameters was used to assess the risks associated with highway transport of Hydrazine.
- Leonelli, Bonvicini and Spadoni (1999) present the new detailed numerical procedures for calculating risk measures in hazardous materials transportation.
- Bonvicini, Leonelli and Spadoni (1998) provide an application of fuzzy logic to the risk assessment of the transport of hazardous materials by road and pipeline in order to evaluate the uncertainties affecting both individual and societal risk estimates.
- By Goh, Ching and Tan (1995) a methodology has been developed for the risk analysis of road transportation of hazardous chemicals in Singapore.
- Philipson and Napadensky (1982) present a structured review of the types of methodologies employed in estimating the contribution to risk of the different phases of a hazardous materials incident, and then review the procedures available for the evaluation of the significance of the risks estimated, and of potential means for their mitigation.

Some other papers have focused on studying HAZMAT transportation incidents:

- Rogers and Sorensen (1989) studied warning and response in two hazardous materials transportation accidents in the U.S.
- Haastrup and Brockhoff (1990) compared between transportation and fixed installations of hazardous materials and severity of their accidents.
- By Price, Schmidt and Davis (1982) a method was developed to estimate the number, types and locations of hazardous materials highway transportation accidents in Virginia.

The third category of papers studies the effects of such factors as regulation (Colen 1987), facility location (Current and Ratick 1995), security requirement (Glaze 2003), and type of hazardous materials.

It is observed that neither of the papers have had a comprehensive approach for dealing with the origins of incidents and/or the manner of preventing them and, most often, their approach has been technical and tactical. In other words, there has been no attention to the application of strategic planning in HAZMAT transportation till now. Using one of the most powerful tools of strategic planning, namely strengths, weaknesses, opportunities and threats (SWOT) analysis, in this paper, the manner of transferring from current dangerous situation of HAZMAT transportation to a cleaner situation is studied.

For this purpose, first the current citation is studied from different aspects and the gathered information is organized in SWOT matrix. Then, suitable strategies for confronting those 4 groups of factors are extracted. Afterwards, some examples of most important accidents are analysed and the role of extracted strategies for preventing them is studied.

3. Overview of the status quo

In this section we will first look at the safety of the country's transportation system and its significance to the national transportation system. We will then go on to define risk and factors that affect it. Controllable and non-controllable variables will be looked at from the perspective of safety transportation planners on a national scale and their present status will be appraised.

3.1. National transportation safety organizational system

Implementation, program development and control and national safety guidelines fall within the responsibilities of the TTO, railroads, Iran's Shipping Organization, and Airlines. Railroads, shipping, and airlines are mostly made up of state institutions and are compliant with international regulations. They are usually administered by complex management systems and are overseen by the Ministry of Road and Transportation.

However, the case of road transportation is different as TTO does not own transportation companies and only serves as a planning organization linked to the Ministry of Road and Transportation.

Transportation safety of hazardous materials is dealt with at this organization's Safety and Traffic Office affiliated to the Deputy of Transportation. Some of the responsibilities of this office pertinent to the transportation of hazardous materials are as follows:

- evaluation of technical specifications of the transportation fleet and provision of recommendations for the improvement of the fleet's condition;

- technical inspection and the issuance of technical inspection permits for transportation vehicles in cooperation with the police;
- overseeing compliance with freight transportation regulations on the roads and regulations related to the transportation of special traffic cargos;
- issuance of transportation permits for special cargos;
- provision of recommendations for cargo transportation regulations on roads;
- development and implementation of traffic statistics plans;
- evaluation of road accident statistics for locating dangerous road locations;
- provision of recommendations on the use of advanced technology for reduction of violations and traffic control on roads;
- provision of necessary plans for the control of the technical situation of vehicles in order to reduce road accidents;
- evaluation of the safety and traffic conditions of roads and provision of solutions for accident reduction and increase of traffic safety rate;
- in what follows we will look at factors intensifying the danger of transportation of hazardous materials and their relationship to the aforementioned points.

3.2. Factors intensifying the transportation danger of hazardous materials

Transportation risks are related to the frequency of accidents (crashes, diversions, etc.) and the magnitude of each accident (in terms of fatality, financial and environmental damages). In order to reduce risks, factors affecting the likelihood and magnitude of accidents must be identified and contained. In what follows, we will divide these factors into two categories.

3.2.1. Factors affecting the frequency of accidents

Safety Quality of Road Networks. Compared to advanced countries, the safety of Iran's roads is far from the optimal level. Last year the number of road traffic deaths rose to 38,000. Improvement of present conditions will be contingent upon the development of road networks, construction of highways with good asphalt and sign quality. The present trend, however, is not promising as most efforts are short-term with limited effects (such as identification of accident-prone locations). Therefore, the probability of improvement in the near future is limited and this variable can not be considered a control variable in the hazardous materials transportation planning.

Frequency of Movements of Hazardous Materials. There is no doubt that as movement of hazardous materials increases in number, probability of accidents rises commensurately. Number of movements is linked with the consumption and production rates of hazardous materials. This factor cannot be viewed as a controllable material as economic development affects the production and consumption rates of these materials. This growth, however, can be contained through the adoption of sustained development policy. Yet decision-making in this area depends on environmental planners and policymakers of the country.

Operational Plan for the Transportation of Hazardous Materials. Operational plan refers to the scheduling of departure and stops of the vehicle. The transportation route can affect the probability of accidents. The shorter the route and the less dangers on the way of the vehicle, the less accident-prone the movement of hazardous materials will be. These factors can be affected by determining the departure and destination points, developing regulations for route selection and avoidance of certain portions of the network. The effectiveness of decisions in this area depends on the diversity of various choices (such as possible transportation routes), criteria of stakeholders (such as transportation companies and industries), their acceptance level, and observance of safety regulations.

According to road transportation regulations, the movement of hazardous materials around Iran must be coordinated with the Road Maintenance and Transportation Organization. Yet the manner in which routes are selected and the route evaluation criteria are not determined.

Also the scheduling of the movement can be effective. Long drives exhaust the driver, hence increasing the probability of accidents. Suitable scheduling can resolve this situation. The road transportation regulation clarifies that movement of hazardous materials can not take place during the day. The organization can specify scheduling plans, involving movement routes and stop points.

Condition of the Transportation Vehicle. The condition of the transportation fleet can also affect the probability or frequency of accidents. The better the condition of vehicles, the less the frequency and probability of accidents will be. A number of efforts can change the condition of the transportation fleet, namely development of safety standards for freight vehicles, maintenance and repair standards together with their scheduling, use of safety signs and the way they should be used, and regulations making these efforts mandatory.

There are no specific safety standards for hazardous materials transportation in Iran and transportation companies are not forced to observe specific maintenance schedules for their vehicles. However, the road transportation regulations stipulate that HM transportation vehicles must be inspected at specific intervals and secure a license from a credible institution. Also, standard safety signs and their proper usage are covered by these regulations.

Workforce Conditions. Drivers' awareness of the dangers associated with the load they carry will encourage them to observe transportation regulations and drive cautiously, factors which by themselves lead to a reduced rate of accidents. Also, the skills and health of the driver are factors that play a role in accident reduction.

In the transportation regulations, specific provisions are made for drivers and helps. Minimum and maximum ages are set; and it is stated clearly that their driver's license must be suitable to the type of cargo they carry. Also, it is maintained that only those companies

that organize educational courses based on TTO standards would be granted approval.

3.2.2. Factors affecting the intensity of accidents' repercussions

- ***Shock-resistant Containers of Hazardous Materials:*** The more the resistance of HM containers, the more time for administering adequate reaction to possible accidents will be, and therefore the negative implications of the accident can be contained. Manufacturing of containers and packaging of hazardous materials in Iran are carried out according to specific standards, which must be observed according to Hazardous Materials Transportation Regulations.
- ***Selected Transportation Operational Plan:*** Adequate planning can contain the implications of accidents. Driving through less crowded routes and at time when there is less traffic can reduce the probability of accidents. Routes can be chosen in a way as to avoid sensitive environmental areas.
- ***Other Actions:*** Use of aids such as warning and communication systems and keeping an eye on the position of rescue teams alongside the transportation networks, training of drivers in handling various accidents, adequate maintenance plans for containers and tanks fall within this category.

3.3. Evaluation programs

Given the present condition of hazardous materials in Iran and an analysis of existing regulations lead us to the following conditions:

- continuous improvement has not been foreseen;
- information gathering and decision support systems do not exist;
- there are no management standards;
- evaluation indices for danger and other factors are lacking;
- the clear positioning of dangerous installations does not exist;
- regulations have been imported/translated and do not suit existing conditions and this factor can increase the danger (for instance, the movement of a fuel truck at night and the driver's attempt to reach the destination sooner led to 90 deaths);
- there are no incentives for supporting safety management systems in firms.

4. SWOT analysis

Based on literature review and interview with experts a list of existing opportunities, threats (to), strengths and weaknesses of Iran's HM transportation system was developed, based on which adequate strategies can be developed. The list of these factors is as follows:

4.1. Strengths

- S1 = Devising new regulations and government's increasing focus on the transportation of HM over recent years;
- S2 = Separation of government (monitoring role) and the private sector (contractor) in the transportation field as opposed to other economic sectors in Iran that are governmental (Ghazinoory and Huisingh 2006; Ghazinoory 2005);
- S3 = Implementation of a number of training programs for road transportation companies over the past few years.

4.2. Weaknesses

- W1 = Numerous deadly accidents over past years;
- W2 = Obsolescence of transportation fleet;
- W3 = Absence of or weak safety management systems in companies transporting dangerous materials;
- W4 = Weakness of detailed operational plans (such as danger measurement methods and danger level criteria definition);
- W5 = Weak research organization and information gathering on transportation of hazardous materials.

4.3. Opportunities

- O1 = Introduction of new technologies (GIS, ITS, …);
- O2 = Greater public opinion sensitivity towards environmental issues;
- O3 = Increased level of technology and standards adopted by auto manufacturers in Iran;
- O4 = Vast plans of railway development throughout Iran;
- O5 = Government's established duty in resolving accident-prone areas of transportation network.

4.4. Threats

- T1 = Iran's roads are highly unsafe;
- T2 = Sharp increase in the number of automobiles;
- T3 = Increased transit of goods, especially petrochemical and chemical materials to neighbouring countries;
- T4 = Sharp development of the industrial sector, especially petrochemical and chemical industries;
- T5 = Private ownerships of trucks dimming the chance of legal follow-up further to accidents (involving the death of the driver/owner).

5. Developing strategies

Analyzing the SWOT elements, a number of strategies ensued that can undergird governmental efforts to reduce HM transportation risks.

The following table (Table 1) contains the list of these strategies together with their characteristics. Each of the strategies is then explained:

5.1. One of the main problems is lack of motivation and training among truck drivers and other personnel associated with hazardous materials transportation work. In addition to methods and systems that are not standardized there are limited standardized

Table 1. Table of derived strategies

Row	Strategy	Responsible Organization	Related Variables				Time Frame
1	Continuous improvement of drivers' skills standards, truck specs, loading methods, packaging, and the transportation operations	Road and Transportation Ministry and Standards Institute		3&5	3&4	1&3	Continual
2	Construction of pipeline for the transportation of oil derivatives	National Oil Company	2&3&4		1&2		Long-term
3	Necessity of using new standards and technologies in hazardous materials transportation	TTO	2	1&3		1	Medium-term
4	Media coverage of dangers associated with the transportation of hazardous materials	Ministry of Road and Transportation	1	2	1		Short-term
5	Necessity of establishing and using safety management systems in hazardous materials transportation companies	TTO	1		3	1	Short-term
6	Creation and organization of specialized hazardous materials transportation companies instead of hiring regular transportation companies and singular trucks	State banks and TTO	5		3	2	Short-term
7	Creation of hazardous materials research center and using research findings in the country's road construction and hazardous materials transportation planning	Ministry of Sciences, Ministry of Road and Transportation		4&5	4&5		Medium-term

regulations in this area that have been mainly adapted and translated. Inspired by the theory of continuous improvement, this strategy suggests that the level of these standards must be properly set and developed. Fortunately over the past years a number of training courses were organized in this area and the country's technological level has improved and the government is responsible by law to follow-up on these activities in order to contain danger on roads.

5.2. Over the past few years the number of automobiles has increased considerably and the heavy traffic has spread to inter-city highways and roads. In addition, in view of industrial development, freight movement has been on the rise. Increased consumption of energy further exasperates this problem. Oil and commodity transit to and from Central Asia are expanding. In this light, the construction of oil pipelines for the transfer of oil would be economically advisable and can contribute to risk reduction on the roads. In addition, the growing number of automobiles necessitates increased gas imports, requiring the movement of gas/petrol tankers on the road and thereby enhancing risk.

5.3. Fortunately, introduction of new communication technologies such as GIS and ITS over the past years and the utilization of novel ABS break technology have led to reduced human error in prompting accidents. In addition, observation of new environmental standards and quality by the auto industry together with road construction efforts lead to risk reduction. The government must enforce the use of these standards and technologies throughout the transportation system, especially when it comes to the transportation of hazardous materials in order to decrease risks.

5.4. Creating public awareness is a suitable means for furthering policies. Over the past years, Iranian media and papers have been able to create an awareness wave and thus force policymakers to implement their suggested political and/or social program. Given the high mortality rate associated with hazardous materials transportation in Iran, public media can be encouraged to create public awareness on this issue so that the government and parliament can allocate sufficient budget for the reduction of risk associated with the transportation of hazardous materials.

5.5. The fact that transportation firms forego the usage of safety management systems is one of the main risk factors. Despite new regulations, the government has not paid sufficient attention to this issue which deserves due emphasis.

5.6. One of the main problems besetting Iran's transportation system is that trucks are used by their owners and since in 50 % of the accidents the driver is killed there is no way to make legal follow-ups. It is in this light that the government seeks to organize these trucks in the context of firms. Given the specific attributes of hazardous materials it would be best for qualified firms to handle safety management standards and systems.

5.7. Though the issue of reducing risk associated with hazardous materials transportation has received due attention, the issue remains under-researched in Iran. Therefore, it is necessary for the Ministry of Science, Research and Technology to create a research centre in this area and incorporate research findings into the decision-making process affecting long-term investment in road and railway construction.

Table 2. Accidents involving the transportation of hazardous materials in Iran

Row	Intensity (deaths)	Type of Substance	Relative Frequency	Factors				
				Driver	Network	Vehicle	Loader	Other
1	Over 50	Solid and inflammable liquid	2 per year	1	2	1		1
2	Over 20	Inflammable liquid and acidic materials	3 per year	3	1	0	2	3
3	Less than 20	Gases and inflammable materials	6 every 2 months	*	*	*		

6. Discussion

As mentioned in the introduction, the number of accidents involving hazardous materials in Iran remains high relative to the rate of material movement. Fortunately, not many accidents led to the loss of lives or damage to the environment. However, they remained threatening to the lives of many and have even at times led to serious injuries and deaths.

We divide accidents involving hazardous materials into three categories, based on the intensity of the accident: ranging from accidents involving more than 50 deaths to accidents with no major injuries or deaths. The frequency and factors leading to these accidents are noted in Table 2. It bears mention that table information was obtained from papers and the less the intensity of the accident, the less exact the information surrounding it.

Due to this reason, we will focus on accidents involving more than 50 deaths or injuries. We will try to analyze these incidents based on existing information on road accidents.

The greatest accident recorded in Iran's history of hazardous materials transportation was the explosion of train wagons carrying dangerous substances in the Khorasan province. In this incident, 46 wagons carrier of hazardous materials (nafta, ammonium nitrate, cotton,…) exploded in a railroad station and as a result 283 persons were killed while hundreds were injured.

The cause of the accident was the sidetracking of the said wagons at one station and their ultimate explosion in another station. Among factors contributing to the gravity of the accident, the following were stressed: permission issued to enter the station after fire was initially contained; unawareness of firefighters about wagon contents; use of water for containing fire had the opposite effect of causing explosions and secondary fires and this was while people had gathered around thinking that the situation was under control. Another issue was the linking of 46 wagons transporting hazardous materials.

However, one point worthy of mention was the timely information dissemination to passenger trains that succeeded in averting the accident scene, thus saving 300 lives.

Another major accident took place at a checkpoint in the Sistan-Baluchistan province (in southeast of Iran). There a speeding gas truck could not come to a halt due to break failure and thus collided severely with buses and cars parked at the checkpoint. The truck caught fire and exploded, as a result of which 90 persons were killed and 114 wounded.

In this accident in addition to violations of committee by the driver (who was speeding in order to reach destination), brakes failed to operate and the location of the checkpoint was also inadequate. The intensity of the accident was affected by a number of factors: the inadequate safety technology of gas truck; the sensitive situation of the checkpoint resulting in the long queue of vehicles, and the long-term storage of contraband commodities (such as petrol).

In case of three accidents involving 50 injuries each, one incident involved the explosion of a liquid gas bunker and the two other cases were caused by non-standard trailers carrying corrosive acids. In all three cases, reckless driving was the primary cause of accident and the intensity of the gas bunker accident was due to the fact that it took place in a heavy traffic zone. In case of the trailers, inadequate and non-standard packaging and loading of materials caused the accident.

In analyzing the factors in case of above and other accidents it bears mention that the separation of factors, i.e., driver, network, vehicle, loading, and other variables does not denote that these factors are independent from one another, as inadequate networks increase the frequency of driving violations or inadequate planning can lead to greater use of dangerous routes on the network.

In addition, in the transportation of hazardous materials, dangers in transportation planning were overlooked. Unsuitable planning does not cause accidents by itself but can increase the chance of accidents taking place. For instance, in the Sistan-Baluchistan accident, the inappropriate transportation schedule led to driving violation and hence accident. In case of the truck that fell behind the dam, question arises as to why such a transportation route was selected?

A question that can be raised at this point is whether the adoption of preventive strategies can prevent the recurrence of past accidents? Can these strategies help contain the negative consequences of hazardous materials' transportation?

To answer the above questions we will show that the long-term effects of adopting these strategies can help prevent the recurrence of such problems and will therefore reduce the frequency and intensity of accidents associated with the transportation of hazardous materials.

The first continuous improvement strategy would be to improve the standards of the driver's skills, loading methods, and the transportation operations. By improving these standards and their enforcement (Strategy 3) the frequency of the following factors will decline: accidents caused by driver's mistakes, leaking of dangerous substances in the aftermath of accidents, occurrence of accidents in highly populated areas or high traffic routes, accidents caused by using dangerous roads.

As pointed out previously, the main causes of accidents are driver's mistakes and use of non-standard holders and tankers for hazardous materials. For instance, in case of the Sistan-Baluchistan accident main contributors were the driver's speed, low safety standards of fuel tank, and bad scheduling of transportation and/or selection of inadequate routes.

By adopting the foregoing strategy, probability of accident occurrence will decrease. With regard to the foregoing example, one of the key factors was the necessity of petrol transfer by tanker, which could have been carried out by pipelines in case the pertinent strategy had been selected. (Gas transfer, following a strategy of encouraging usage of gas combustion engines and thus reducing the need for the transfer of petrol and thereby containing the contraband of this commodity). The adoption of this strategy will reduce the need for the transportation of liquid gas by bunkered trucks, limiting probability of accidents for this type of vehicles, especially the kind of accidents referred to in paragraph 2 that led to 20 deaths.

One of the main causes of accidents in the past was lack of attention and awareness about the dangers associated with the transportation of hazardous materials (factor that was underscored in the 4th strategy). Had people been aware of the dangers of hazardous materials transportation, they would have exerted more care when approaching or passing vehicles carrying hazardous materials. In such case the frequency of these accidents would have been considerably reduced. Or in case of the Neishabour accident, instead of gathering around the location of the accident, they would have cooperated with fire fighters; or else, they could have prevented the movement of dangerous materials in the vicinity of their houses, thus forcing local officials to observe safety measures.

Lack of attention to adequate safety measures is due to transportation companies not using safety management systems. Had such systems been used, each activity would have been measured and commensurate resource would have been allocated to it according to adequate planning. In case of the Neishabour accident, non-observance of safety measures regarding the transportation of hazardous materials and inattention of railway guards led to the sidetracking of the wagons and the ensuing accident. Also, the timely notifications about the impeding danger led to the rescue of hundreds of lives and this very factor underscores the sensitivity of using safety systems leading to adequate and timely policies.

Another role of the safety systems is the gathering of and access to accurate transportation information. If firefighters had adequate knowledge of the hazardous substance they could have taken more effective measures in containing the blaze and secondary explosions of the wagons could have been effectively prevented.

The probability of adequate management and implementation of the foregoing strategies can only increase if specialized transportation firms undertake the movement of hazardous materials. As such not only better controls can be implemented, but the process can become more economical. This would be possible only through the adoption of the 6th strategy. In the final analysis, it can be maintained that better and more effective strategies are only possible on the basis of better knowledge and information. This very fact in itself supports the necessity of research and study in the field of transportation of hazardous materials through the adoption of the 7th strategy.

7. Conclusions

This article addressed the issue of hazardous materials transportation in Iran from a strategic perspective. It was noted that the implications of hazardous materials transportation in Iran were such that a review and reform of plans and past actions were in order.

Next, the existing situation of hazardous materials transportation in Iran was overviewed. It was maintained that Iran's transportation safety systems account for issues related to the transportation of hazardous materials. There are rules and regulations that specifically address this issue; nonetheless, the management of the hazardous materials transportation in Iran has yet to develop as it is beset by major weaknesses.

Also in an overview of factors affecting risks associated with hazardous materials transportation two sets of factors were mentioned: factors that affect the frequency of accidents and factors affecting the scope and intensity of an accident. Regarding the former, it was mentioned that Iran's rate of accidents is one of the world's highest (23,000 deaths per year) and this very factor necessitates greater focus on the safety management of hazardous materials transportation. Also, the frequency of hazardous materials transportation is on the rise due to the process of industrial development (in such sectors as oil and energy). Nonetheless, hazardous materials transportation regulations stop short of mentioning generalities on transportation operational plans, the situation of the vehicle and driver. Though this is a good beginning, necessary software and hardware for developing effective processes must be accounted for and a method for the continuous improvement of regulations must be considered since their inapplicability to the current transportation situation in Iran may heighten existing risks.

On factors affecting the scope of accidents it was mentioned that packaging techniques and resistance of containers of hazardous materials, operational planning and other issues such as use of warning systems and driver's education are useful. In these areas, steps such as definition of packaging standards and container standards were taken; nonetheless, there seems to be a need for continuous improvement and implementation of guarantee mechanisms.

After an overview of the current situation and drawing upon the viewpoints of experts on existing threats, weaknesses, opportunities, and strengths, the latter were categorized and summarized, giving way to the suggestion of strategies on improvement of hazardous materials transportation in Iran.

The suggested strategies will have to be implemented and evaluated in order to be further improved in the future.

The Management and Planning Organization – that develops national development plans and annual budgets – must allocate adequate budget to these strategies and direct relevant organizations towards their implementation. Regarding bureaucratic hurdles in Iran that make the implementation of such programs difficult, a look at the 9th reference would be useful. Also, it appears that further research into the following topics would be advisable:

- Determining the possibility of using Sequencing and Scheduling models for adequate scheduling of hazardous materials movement on Iran's roads;
- Determining the possibility of relocating a number of industrial units that require the transport of hazardous materials (for instance, a number of research units are as far as 1000 kilometers from oil fields);
- Calculating risks associated with the transportation of hazardous materials transiting through the Iranian territory and originating from neighbouring countries;
- Probing greater use of CNG (transferred via pipelines) instead of petrol as primary fuel used for vehicles which is usually transported by tanker trucks (this method is also very economical and environmentally friendly).

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