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Analysis of Risk and Vulnerability Assessment of Existing Water Supply Facilities Mahshahr Special Economic Zone

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Water facilities are among basic infrastructures in any country. In case of lack of preparedness and preventive and predictive programs and suitable staff training, any potential damage to these facilities may result in crisis and have adverse health, political and social impacts. Water transfer and distribution systems are one of the main elements in water supply facilities which are subject to qualitative and quantitative risks resulting from dangers and natural threats (earthquake and floods) as well as man-made risks (e.g. unstable flow, corrosion, high pressure, executive operation, etc.).Accidents in water supply networks especially water transmission lines annually create considerable damage for organizations. Negligence to potential dangers and determining vulnerability and risk in design, utilization and maintenance stages of facilities may create irreversible costs for operation of the water utilities, side facilities and the environment. Using methods based on hierarchical series and fuzzy inference system, risk analysis in water transmission system from Koot Amir Water Treatment Plant to Mahshahr Special Economic Zone was done. This system is composed of a collection of pipe lines, canals, and pumping stations, and supplies water needs of Mahshahr Special Economic Zone as well as drinking water of some cities and towns on its path, and it is considerably important economically and socially.

Keywords: Risk analysis, hierarchy analysis, fuzzy inference system, water supply, Mahshahr Special Economic Zone

Mahshahr Special Economic Zone located in one of the important and strategic ports of country is situated in Khuzestan province with 2,713 hectares area. It is the widest city of Khuzestan after Ahvaz.

This city is located in 18 km distance to Imam Khomeini port and 95 km to Abadan and 100 km to Ahvaz. Mahshahr Special Economic Zone includes several petrochemical plants, and it makes Mahshahr as a major petrochemical base in Iran[1]. Figures 1 and 2 show aerial images of Mahshahr Special Economic Zone.

The water of complex in Mahshahr Special Economic Zone is currently supplied through Karun River and The Koot Amir Water Treatment Plant with over 100 kilometer transmission lines and canals. Fig. 3 shows current status of water supply in special petrochemical economic zone. Current conditions of water supply with 400000 m^3 daily suffice in terms of volume for current consumption[4]. However, due to increased

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human activities including industry, agriculture and drinking, creating new facilities on the Karun River, increasing water usage from the transmission line route, high length of transmission lines and probability for any accident on the route and potential drought which may affect Karun River water, have created such conditions that cause concern for authorities in Mahshahr Special Economic Zone and challenges have been developed in this regards. Thus, investigating threat factors and risk analysis in water supply in Mahshahr Special Economic Zone is one of the priorities in the region's plants[5]. Diagram 4 shows discharge changes and Fig 5 shows TDS changes in Karun River during 1967 – 2005 [4].

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MATERIALS AND METHODS

The algorithm proposed in this research is the extended form of the model provided by Federal Emergency Management Agency (FEMA) for major and critical infrastructures. This instruction was originally provided for confrontation with Man-Made Threats and Malevolent Threats for sensitive governmental and public centers. The salient point in this instruction its ease of use and perfection. Fig 6 shows the model provided by FEMA[6].

Step 1 : Threat Identification and Rating

In this step, potential malevolent threats for the system are identified and rated by developing rating criteria by the experts. Of course, according to FEMA instruction, threats with high score are selected for the subsequent steps.

Step 2 : Asset Value Assessment

Aim of this step is in facto estimating severity of physical and financial damages on one part of the system due to a specific threat. Damage severity against threats is specified in this step by identification of critical assets, defining criteria and related thresholds for each part of the system.

Step 3 : Vulnerability Assessment

In this step, vulnerability potential of critical assets against identified threats is calculated. This step is accompanied by a series of criteria and thresholds.

Step 4 : Risk assessment

With completion of three previous steps, risk of each part of the system is specified in this step. Risk for each part is obtained using relation 1:

Vulnerability Rating ×Threat Rating ×Risk = Asset Value

(Relation 1)

Asset value in this relation denotes importance of each element in the system and amount of physical damage due to destruction. Threat rating specifies danger and threats for the element. Vulnerability rating shows vulnerability of the element based on current measures for coping with threats and specifications of the element.

In order to quantifying the risk, FEMA suggests considering 10 different classes with values between 1 to 10 for three above factors and risk rating is calculated quantitatively for each element by multiplying above three factors[6].

Step 5 : Consider Mitigation Options

In this step, one can determine which parts should be controlled and how needed measures for risk reduction should be done. Implementing this step after specifying risk value is for each critical part and it is codified based on results taken from previous steps of risk coping policies. For example, risks with very low rating can be accepted.

Valuation of Transmission Line Assets

Various parts of transmission line for weighting are as follows, based on which the

Fig. 1. Situation of Musa bay and Mahshahr Special Economic Zone toward Persian Gulf[2]

questioner 1 was prepared and given to experts. In this classification, it was attempted to investigate

Fig 2. Aerial image of Mahshahr Special Economic Zone[3]

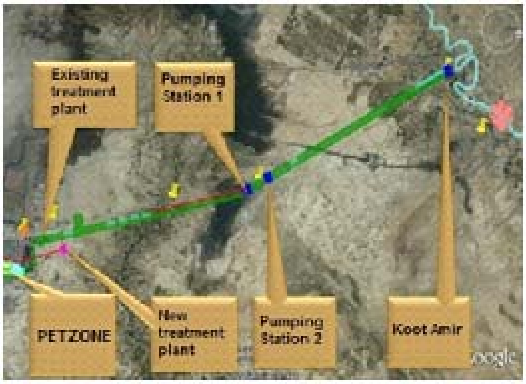

Fig 3. Current status of water supply in Mahshahr Special Economic Zone[4]

all project infrastructures. The first questionnaire is related to valuation of transmission line assets. Fig 3 shows position of facilities in this transmission line.

1. Karun water harvesting facilities
2. Koot AmirTreatment Plant
3. First part of transmission line (including a portion of the transmission line between Koot Amir Treatment Plant and Mansooripumping station 2 and has a length of about 37 km)
4. Mansoori pumping station 2
5. Second part of transmission line (including a portion of the transmission line between Mansoori pumping station 1 and 2 with a length of 8 km)
6. Mansoori pumping station1
7. Third part of transmission line (including a portion of the transmission line betweenMansoori pumping station 1 and Sarbandar's new treatment plant branch with a length of about 35 km)
8. subscriptions relating to Sarbandar's new treatment plant
9. Fourth part of transmission line (including a portion of the transmission line between Sarbandar's new treatment plant and Sarbandar'sold treatment plant with a length of about 5 km)
10. subscriptions relating to Sarbandar'sold treatment plant
11. fifth part of transmission line (including a portion of the transmission line which transfers water after Sarbandar'sold treatment plant to Mahshahr Special Economic Zone with a length of about 5 km)[4].

Non-fuzzy value of above fuzzy functions was calculated shown in Diagram 7. Importance of different parts of transmission line is shown in this figure as weight percent.

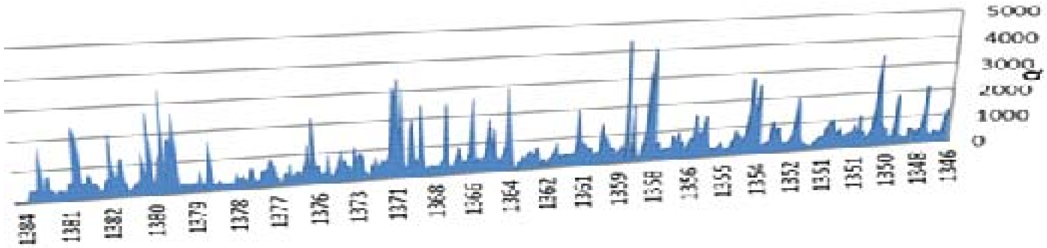

Fig. 4. Discharge changes (cms) of Karun River during 1967 – 2005 [4]

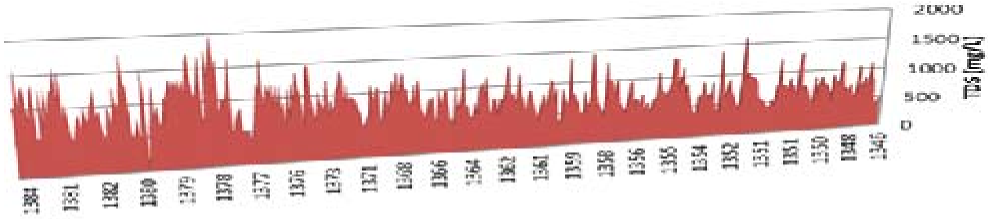

Fig. 5. TDS changes (mg/L) of Karun River during 1967 – 2005 [4]

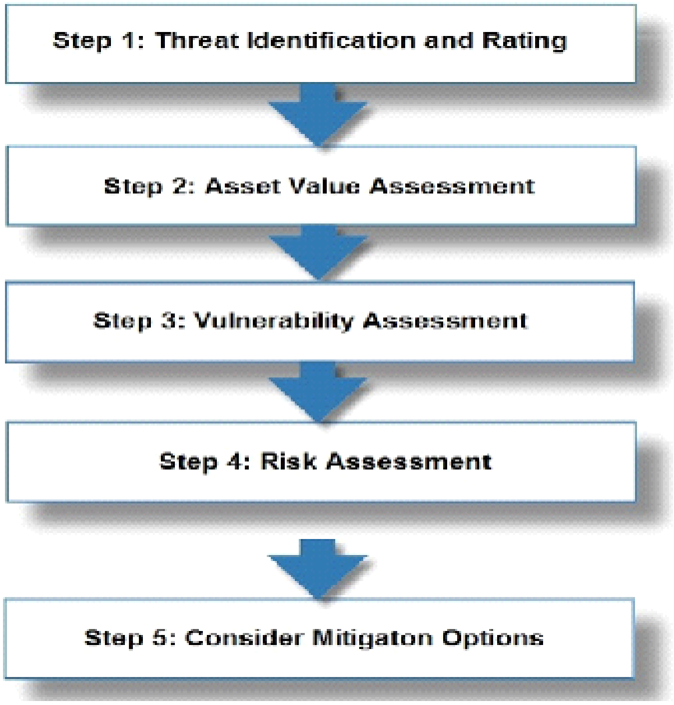

Fig. 6. Major steps in risk assessment and management model[6]

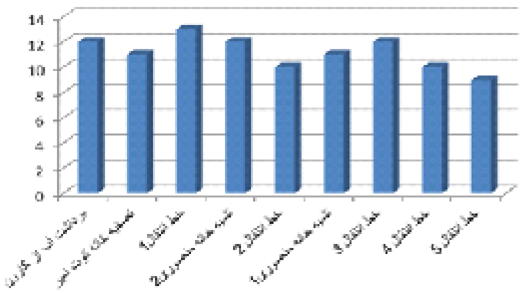

Fig. 7. Weight percent of different parts in transmission line (valuation of assets)

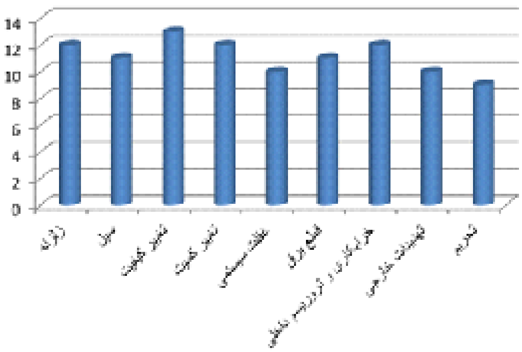

Fig 8. Weight percent of threats in different parts of transmission line (weighting threats)

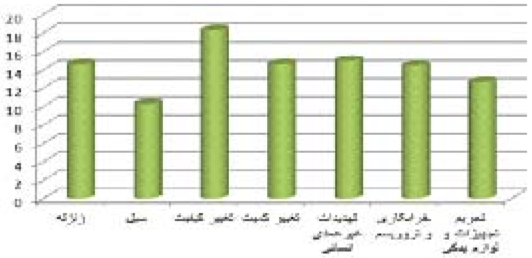

Fig. 9. Risk percent for threats in facilities and equipment of Karun water harvesting

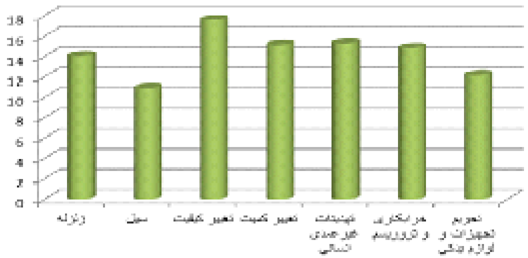

Fig. 10. Risk percent for threats in Koot Amir Treatment Plant

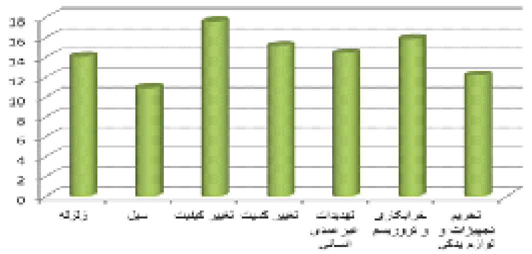

Fig. 11. Risk percent for threats in Mansoori Treatment Plant 1 & 2

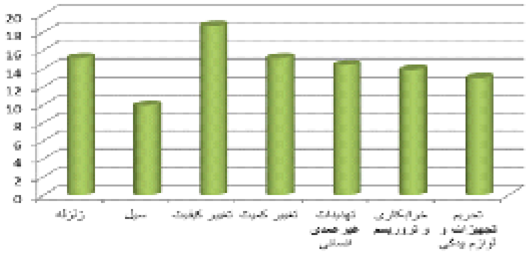

Fig. 12. Risk percent for threats in the whole transmission line

Weighting Threats

Selected threats for weighting include natural threats, earthquake, floods, drought, changes in the quantity and drought in Karun, Karun water quality changes and man-made threats (intentional and unintentional).

To this end, questionnaire 2 was prepared and given to experts in threat recognition area.

Non-fuzzy value of above fuzzy functions was calculated shown in Diagram 8. Importance of threats in different parts of transmission line is shown in this figure as weight percent.

Vulnerability Rating

Following analysis of results taken from questionnaire 1 and valuation of different parts of transmission line, the important assets were selected. According to obtained results, value of all pipe lines is identical. In the next step, according to results taken from questionnaire 2, threats with the highest weight were selected as the basic threats. With selection of main assets and basic threats based on questionnaire 3, vulnerability rating of assets due to threats was investigated. Non-fuzzy values of fuzzy functions of facilities and equipment in transmission line are calculated.

CONCLUSION

Considering results taken from above questionnaires, risk rating for threats to selected facilities was specified. Given obtained risk rating, it is specified which part has the highest risk, and necessary measures can be taken for risk management with prioritizing risk ratings. Following analysis of questionnaires and based on Relation 1, risk percent in different facilities along transmission line was determined. Obtained risk value suggestwhich part has highest risk in transmission line, and required actions can be done for risk management with classification of risk percent.

Considering obtained results in previous sections, risk percent in facilities and elements of transmission line is calculated, values of which are shown in Fig 9-12.

Considering obtained results and calculated risk values, it is observed risk value obtained in facilities and equipment of transmission line due to potential threats are very similar and it may suggest in the view of the respondents any problem along different parts of transmission line which cause lack of water supply for Mahshahr Special Economic Zone is unfavorable and has the same value, as the source of water supply is the same and supplying water needed in this area is not possible in other way. On the other hand, among potential threats, changes in water quality and quantity, earthquakes and intentional man-made threats have the greatest risk.

Results obtained from hierarchy analysis for Karun water harvest, treatment and transmission systems showed that concern of authorities in Fajr Complex in MahshahrSpecial Economic Zone (which is responsible for all utilities units of the special zone) for presence of risk in water supply and transmission from this soruce is due concern andprudence in risk management and emergency conditions can prevent from severe technical and economic damages. In this step, it was concluded highest weight percent of the system elements in terms of vlaution of assets is related to transmission line especially Transmission Line 1 and then Karun water harvest system and Mansoori Treatment Plants.

Thus, in order to reduce risk, necessary measures should be taken so that little difficulty is faced in emergency situations. Generally, the following can be effective in reducing the risk of pipelines:

1. Developing EOP and ERP plans for each of the facilities and equipment of the transmission line.
2. Establishment of HSE system along the transmission line.
3. Performing maneuvers to counter any threats. The time required to eliminate the threat should not be longer than this time considering water storage capacity.
4. Prediction of alternative water supply system for use in emergencies
5. Providing remote monitoring and pressurecontrol over the transmission line (Real Time Monitoring)
6. Creation of protection and safety to eliminate access to transmission lines and associated facilitiesforpersons other than responsible ones.
7. Storing equipment, valves, pumps and some pipes at the same size with transmission line in a suitable place for repair and replacement if necessary.
8. Presence of a specialist team for operation and daily visit to the transmission line
9. Creating an alert system for operators when any incident occurs.
10. Predicting emergency power systems when any incident occursor power failure
11. Retrofitting all facilities and equipment in transmission lines to deal with earthquakes Using flexible connectors to minimize the likelihood of damage during the incident.

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