# Evaluation of the performance of the support-wavelet vector machine hybrid model in predicting dust storms (Case study: Sistan and Baluchestan province)

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## Introduction

In recent years, the use of combining meta-models with optimization algorithms to predict hydrological and meteorological variables has increased, some of which are mentioned below. The results of research on drought prediction using genetic algorithm and hybrid neural-wave network model showed that the application of the combined method in comparison with the combination of genetic algorithm and neural network provides desirable results [5]. The study of the performance of hybrid models of artificial neural network and support vector machine in estimating the discharge of Zarrinehrood River, located in Iran, showed that the hybrid model of artificial neural network has better accuracy than support vector machine [7]. Long-term rainfall in Anzali over a period of 67 years was assessed by the wavelet numerical model - adaptive neural fuzzy inference system (W-ANFIS). The results of this study showed that the W-ANFIS model with the values of correlation coefficient, dispersion index and cluster instability equal to 0.962, 0.258 and 0.899, respectively, has a good ability to simulate rainfall phenomenon [6]. In this study, SVM meta-model and its combined type with artificial plants (AF) and wavelet (W) algorithms will be evaluated in order to predict the FDSD index in five synoptic stations of Sistan and Baluchestan province. Therefore, this study can be a new approach in how to use intelligent hybrid methods to predict the FDSD index in the study area**.**

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## Materials and methods

In this study, two hybrid methods under the headings of support vector-wavelet (W-SVM) and support vector-artificial plants algorithm (AF-SVM) with individual model of support vector machine (SVM) to predict the frequency of days with Dust storm (FDSD) in five synoptic stations of Sistan and Baluchestan province (Zabol, Zahedan, Iranshahr, Khash and Saravan) were compared with the long-term statistical population of 40 years (1980-1920) on a seasonal scale. For this purpose, horizontal vision power data and WMO codes were used. Observations of meteorological phenomena are recorded every three hours, eight times a day. In these observations, visual phenomena of the weather are defined in 100 codes (00-99) according to the instructions of the World Meteorological Organization, of which 11 codes are generally used to record and report dust phenomena in different meteorological stations [8]. In this study, a horizontal visibility factor was used for all dust meteorological codes to detect dust storms. After selecting the stations and reviewing the data over a period of 40 years (1980-1920), the number of days with dust storm (FDSD) for the five meteorological stations studied in Sistan and Baluchestan province was calculated using horizontal visibility data and Meteorological Organization codes. While, meteorological stations, latitude and longitude, altitude, average FDSD index on a seasonal scale, and the number of dust days can be seen in ascending order.

## Results and discussion

The results of FDSD index forecast indicate the good performance of both AF-SVM and W-SVM hybrid methods in all studied stations (Zabol, Zahedan, Iranshahr, Khash and Saravan). Another point is the poor performance of the individual backup vector machine model compared to both hybrid methods. The hybrid support vector-wavelet model in all studied stations has better accuracy and overlap than other studied models due to the optimization of model parameters by the wavelet algorithm. On the other hand, the support vector machine model-artificial plants algorithm has shown a good performance after the hybrid model of the support vector machine-wavelet. On the other hand, according to the root mean square error and Nash Sutcliffe coefficient, the hybrid backup-wavelet machine hybrid model, again, showed less error and higher accuracy in all selected stations. Mean Absolute Error in two synoptic stations of Saravan and Khash, which have the lowest number of dusty days, the hybrid model of the support vector machine-artificial plants algorithm performed better than the hybrid model of the support vector-wavelet model. However, in other studied stations, such as good fit criteria of the previous one, the hybrid backup-wavelet machine hybrid model performed as the best. In addition, the hybrid model of the support vector machine-artificial plants algorithm has a good accuracy in predicting the intermediate and maximum

values, and as we move towards the minimum values, it increases the accuracy and efficiency of the hybrid model of the support vector machine-artificial plants algorithm. The selection of more complex models is the optimal predictive model in the studied stations; in order to predict the FDSD index in all stations, models 3 and 4 (with three and four steps delay) were used, which can be due to the impact of particles left over from previous storms and seasons. The past has looked to the formation of dust storms next season. The results of this section are consistent with studies conducted in this field [1, 2, 3, 4 and 7]. The performance of all methods for predicting the FDSD index is directly related to the increase in the number of days associated with dust storms. The results of this section are in line with studies conducted in this field [4].

## Conclusion

The results of this study showed that the use of a combined support vector-wavelet model could be very effective in predicting the frequency of days with dust storms. In addition, in all the methods used to predict the FDSD index, the model that used three or four steps of delay in forecasting was the best predictive model, which can be due to the effect of particles. The remnants of previous storms and the previous season(s) sought to form next season's dust storms. Considering that the decision to control dust storms and implement management strategies in many critical areas of the country depends on the accurate estimation of dust storms; therefore, using the proposed hybrid model to predict the FDSD index, can be used as an appropriate tool in management decisions. Undoubtedly, in order to validate the results of this study, more research should be done on the application of hybrid meta-models in modeling and temporal-spatial prediction of dust storms in areas affected by this phenomenon. It is also suggested to use hybrid models of support vector machine with new optimization algorithms such as skiing, chicken swarming, cat swarming, creative rifleman, etc. and compare with the results of the proposed model.

**Kayword:** Artificial Flora, Frequency, Dust Storm, Support Vector Machines, Sistan and Baluchestan province.

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# Analysis of changes in the structural behaviour of the Lar Dam and its potential risks using radar interferometry and field experiments

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## Introduction

Dams are defined as installations used to provide water for various use [1]. Dams also contribute to socio-economic developments by not only providing shelter for the downstream regions by suppressing floods, but also forming reservoirs used for various purposes including irrigation, human consumption, and hydropower. These notwithstanding, current trends in the climate change together with improper management of water resources have increased the risks of flood events and drought as global crises. The collateral damage from these events have also been imposed on dam structures [2].

## Case Study

The case study includes the Lar Dam, located at 85km distance from the North East of Tehran. The area receives an annual precipitation of 600 mm, more than 60% of which is often accumulated as snow. The reservoir is however dry throughout the summer, contributing to only 6% of annual precipitation. Nearly 70% of the total precipitation in the region occurs in winter and spring. The right abutment is located on calcareous formations, while the left abutment is situated on the alluvial sediments and layers of lava originating in the Mount Damavand. The main leakages from the dam have been reported in the karst regions developed on the calcareous formations.

## Material and methods

Data requirements for this study were supplied by acquiring SLC images from the Sentinel-1A sensor the Soyuz satellite of the European Space Agency[1]. The images were taken in 2014 in single polarisation mode (VV) from 28 orbits. Images with similar orbits were initially identified and the 30-meter SRTM digital elevation model was used to process the images. The required DEM files were generated using the GMTSAR software available at (https://topex.ucsd.edu/gmtsar/demgen). The data processing was conducted using interferometric synthetic aperture radar (InSAR) technique. This technique

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1. https://scihub.copernicus.eu

calculates the differences in the phase of waves returning to the sensor to generate an image called the interferogram; which is the differential of phase of two geometrically aligned images taken at two different time StaMPS.

**Results and discussion**

Noisy interferograms obtained for a pair of images were eliminated and a time series of interferograms with the least amount of noise and highest pixel count were identified for later processing. The results were indicative of increasing trends in subsidence at certain points in the dam, from 2015 to 2020. The highest amount of vertical change was identified in the form of subsidence in the left abutment area, progressing towards the Delichay River. From 2018, protrusions started to form in the abutment as it started to swell, requiring further investigations in terms of geology of the region and dam behaviour.

Based on the results of interferometry, the total subsidence and swelling points were observed in three main areas; the middle of the right abutment where vertical deformations were observed in the form of subsidence at downstream and upstream. The highest amount of subsidence in the area were measured at 20 mm throughout the study period, with a sudden increase in vertical deformation from 2018 onwards. The sudden escalation in deformation in the left abutment and dam body is a major cause for concern about the stability and safety of the dam. The main cause of these deformations was identified as breaches in the calcareous and karstic ducts within the reservoir, causing water to seep under the dam structure. Leakage from the karsts and calcareous ducts cause an increase in water flow, which then causes porewater in the alluvial layers to flow to the calcareous ducts. The alluvial particles then fill up the calcareous pores, reducing the shear strength of soil. As a result, the soil particles are carried away from the embankment by water seeping through the dam, causing internal erosion. The prolongation of erosion together with exploitation of the dam throughout the years have caused further subsidence of the dam structure, increasing the odds of a sudden dam failure and the formation of a sink hole. Further cause for concern is the difference in height of the dam riprap overlay. These conditions of impending failure are similar to those of the Mosul Dam, highlighting the need for constant monitoring of the Lar Dam and use of geological data to develop an alarm system for mitigating the potential impacts of a dam failure and increasing safety.

**Keywords:** mnges in structural behaviour of the Lar DaCha Sentinel-1A, Lar Dam, InSAR method.

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# Investigating effective measures of local governance in reducing the effects of drought in rural settlements of Darab Township

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## Introduction

Governance, in the sense of the decision-making process and its implementation, encompasses a set of values, norms, processes and institutions. Through them, community development management is done formally and informally. Governance is related to both government officials and the commitment of citizens, and therefore involves the government and other elements of society at the local, regional and national levels. Governance can be pursued at different political, managerial and administrative scales and at international, regional, national, local and organizational levels. Rural governance is a set of actions through which individuals and institutions, both private and public, manage and administer the village. In fact, rural governance includes formal and informal institutions and social capital of rural residents, which should ultimately enable rural citizens to enjoy the benefits of citizenship.

## Materials and Methods

This research is considered as a qualitative research from the perspective of research paradigm and has been carried out with the aim of exploration (local government measures to reduce the effects of drought). In this study, first, to determine the drought zones of Darab city, the rainfall statistics of 10 rain gauge stations was examined over a period of 15 years using the SPI index. After determining the drought or wet season in each station, using Arc GIS 10.2, zoning of drought areas was created by IDW interpolation method. According to the SPI index, out of 12 villages in Darab city, two villages are in the range of moderate drought and five villages are in the range of mild drought. Then, using the method of fundamental theory and the method of qualitative and semi-structured interviews, zones located in drought zones have been used to collect information and data. Participants in the study are members of Islamic councils and Village leader in 36 villages located in drought zones of Darab town ship.

## Discus and Results

Results show drought zones throughout the city. 41.4% of the city limits are in the mild drought zone and 21.2% are in the moderate drought zone. The average drought area is located in the southeast of the city, ie Forg and Abshour villages, which have lower altitudes than the rest of the city. Mild drought zones are located in the east and west parts of the city. Studies show that local governance in the area of moderate drought, ie Forg and Abshour villages have performed better in reducing the effects of drought. In addition, in villages with higher populations and with more councils and full-time Village leader, more measures have been taken to reduce the effects of drought.

## Conclusion

The results show that important economic measures of local governance in reducing the effects of drought can be encouraged by villagers to diversify livelihoods (88.2%), contribute to the livelihood of affected households by introducing them to donors (86.1%), encouraging the cultivation of high-yield and marketable crops (86.1%). It mentioned the introduction of agricultural products with higher income (83.3%), and encouragement to build greenhouses (80.6). In addition, effective social measures to reduce the effects of drought, including encouraging farmers to use cooperative methods in the production and harvest of crops and horticulture (80.6%), encourage villagers to stay in the countryside (75%), help increase farmers' awareness (72.2%), and introduce social capital experiences to deal with the effects of drought (72.2%). In the field of environmental measures, we can refer to cases such as the introduction of new irrigation methods (86.1%), prevention of pollution of surface and groundwater resources (80.6%), and the introduction of environmentally harmful people to the judicial authorities (77.8%) cited.

**Keywords:** Local governance, drought, rural settlements, Darab Township.

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# Comprehensive analysis of urban resilience in the face of earthquake risk (Case study: Sari city)

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## Introduction

Expanding the urban population to more than two-thirds of the world's population by 2050 on one hand and predicting the growth of natural hazards in the future on the other hand, enforce the need for managers, planners and urban policymakers to pay attention to the issue of greater resilience of communities in the face of natural hazards [12]. Analysis of environmental risk management in Iran indicates the relative failure of harmful effects and their consequences. Accordingly, the present study was conducted with the aim of comprehensive analysis of urban resilience against hazards using factor analysis in Sari.

## Methodology

In this research, using fuzzy Delphi method, according to the opinion of research experts, in three stages, 53 factors extracted from previous studies. Afterward, froming the qualitative process have been confirmed and screened. So, the factors extracted for the exploratory factor analysis process are adjusted. After this step, based on the results obtained from mentioned method, exploratory factor analysis questionnaires have been compiled. After collecting information, exploratory factor analysis questionnaire from 98 experts in the process of urban resilience in Sari city was prepared. These analysis has been explored using the factor analysis approach. The studied variables in order to explain the resilience of Sari city are as follows: the conditions of open spaces, incompatible uses, land (bed), building resistance, access, ownership, density, which are in the presented paradigms of research findings.

Initially, there were 46 factors, which after analysis were classified and screened into 40 sub-indicators in the form of seven indicators. In the meantime, from the point of view of news people, in order to select the appropriate names for the indicators according to the experimental commonalities between them, and to confirm the created model, the process of confirmatory factor analysis (structural equations) using LISREL software has been used. Based on the goodness indicators, the fit of the model related to "urban resilience", all the

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mentioned indicators are at an acceptable level, and therefore the model has a good fit. Figure 4 shows the standard coefficients for this structure. These include following areas: the degree of resilience of arteries and vital centers, the capacity of vital infrastructure, the distance of relief uses (fire, hospitals and clinics), the degree of cohesion of buildings in neighborhoods, diversity of green and open urban spaces, level of age distribution, level of education, and level of income. These areas do not have a significant relationship because their level of significance was less than 1.96. Therefore, they considered as a free component and removed from the final model.

## Results

Urban resilience is one of the most important criteria in the process of urban development and population density in different regions. The higher the level of urban resilience, the more security is guaranteed to live in an urban area. So, policymakers as well as decision-makers in the field of urban management are constantly measuring and monitoring resilience in urban areas, in order to examine the existing weaknesses and strengths to take appropriate measures to correct and improve barriers and problems to increase the level of urban resilience in order to increase capacity at the time of the accident in the urban area. Therefore, it is necessary to correctly identify the factors affecting urban resilience according to the nature and requirements of each urban area. Finaly, a suitable model was created for measuring urban resilience, which measure the level of urban resilience and determine its status, weaknesses and problems, so that the level of urban resilience in the event of natural disasters can be increased.

**Keywords:** Resilience, Factor Analysis, Earthquake, Arteries, Sari.

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# Determining Geomorphological Restricted Areas in Bojnourd City in order to Locate Appropriate Directions of Urban Development from a Hazards Perspective

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## Introduction

Unplanned human activities in the environment lead to various risks and damages from human, social, environmental, and economic aspects that can have catastrophic effects and consequences with the help of planning and preparedness for emergency measures. The location of settlements and other man-made facilities is influenced by environmental factors, especially geomorphology and geology. A population explosion and the expansion of the dimensions and diversity of urban development patterns have accompanied accelerated urbanization and the move towards urbanization in the world. This increase in population in Iran over the past few decades has not been commensurate with the ability to equip urban spaces and expand infrastructure, and has created problems such as expensive housing prices, unemployment, and informal housing in the most severe way possible in the appearance of cities. The city of Bojnourd, as the administrative-political center of North Khorasan province, which has a special place in the residential system of the northeast of Iran, is the 44th city in Iran in terms of population. The rate of increase of urban settlements in Bojnourd plain has increased from 17% in 1998 to 37% in 2013, which has destroyed a large area of agricultural uses and fertile gardens in the Bojnourd plain. Lack of suitable land for allocation to urban uses, economic poverty and inaccurate study and location of urban land uses, has caused the population in high-risk areas such as floodplains, rivers and canals privacy, settle near active faults and points with high water table. This issue has always been one of the concerns of city administrators and urban planners. In the field of locating cities using various natural and human parameters, many studies have been done on many cities inside and outside the country. Especially in recent years due to the importance of the issue, its understanding and the need for research such an upward trend has taken place. Considering that, so far no research has been done on determining the geomorphological restricted areas

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and locating suitable aspects of Bojnourd urban development from the perspective of risk. Therefore, it is necessary to conduct research on this issue in the urban and suburban areas of Bojnourd. The purpose of this study is to determine the geomorphological restricted areas in order to locate suitable aspects of urban development from the perspective of risk in urban and suburban areas of Bojnourd. In this study, with a systemic-environmental perspective, and with the idea that urban geomorphological studies are the basis for identification and management of the environment and risk reduction, by evaluating and locating appropriate spaces and directions of urban development in Bojnourd with geomorphological perspective and the influential components are dealt with systematically.

## Research scope

The study area is the tectonic-alluvial plain of Bojnourd, on which the urban area of Bojnourd and the surrounding towns are located.

This plain is limited from the northeast to Garmkhan plain, from the north to Maneh plain, from the east to Shirvan Township, from the west to Badranlu river basin, and from the south to Esfarayen Township (Figure 1). In the present study, the urban area of Bojnourd and Golestanshahr (Maskane Mehr) was surveyed up to a radius of 6 km based on experts. Physical growth towards high-risk areas, population settlement, establishment of equipment and facilities, and public and private investment in these areas, increased the risk of city limits from flood, earthquake, and water table hazards. These features have caused this city to have a fragmented and island growth. Geomorphological barriers have been the main limitations of development in the privacy of Bojnourd city.

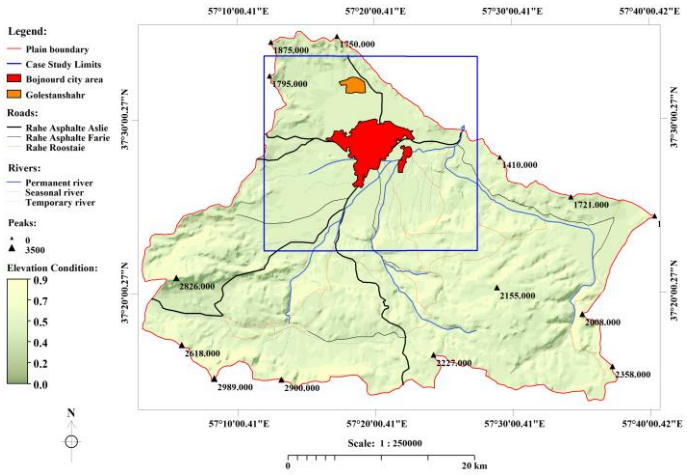


**Fig. 1. Location of Bojnourd city and its surrounding towns in**

## Materials and Methods

Regarding the systemic approach, environmental variables including geomorphological parameters, geology (lithology and active faults), topography (slope, slope direction and altitude), hydrology (distance from rivers and canals), and human parameters (Land use and distance from urban and demographic points) in the study area in the form of classification maps and layer fuzzy operation was performed. Using the ANP model, the final weight of each factor layer in the Super Decision software was obtained. From the multiplication of the final weight obtained from the ANP model with fuzzy layers and using the Fuzzy Gamma 0.5 operator, an integrated map was obtained. The geomorphological restricted areas were identified from the perspective of urban development, the remaining areas of the study area into appropriate, and very inappropriately categories were classified.

## Apply Prohibited Areas

In order to zoning and locating areas prone to urban development, after preparing the information layers, fuzzy layers were attempted and the prohibited areas were identified. Considering the purpose of the present study, which is to determine the prohibited areas and apply these areas in the location of urban development, by giving zero score to the prohibited classes, fuzzy construction was performed.

## Results

The results showed that 57.7 KM2 equivalent to 21.24% of the study area, according to the existing standards and conditions, is a restricted area, which often corresponds to the eastern, northern and northeastern parts of Bojnourd. That is, the bed and river bed privacy of Firoozeh River, and the intersection of Halghehsang, Malkesh, Pesteh, Doberar, Aghghaleh, Gheshlagh, Langar, Baghchegh , Aliabad canals and the adjacent points of the Chaharkharvar-Babaaman, Doberar-Borj fault systems and the torn and hidden fault that it corresponds to the bed of Firoozeh river (Figure 2). From the total area of study area, 58.3 KM2 equivalent to 15.84% includes the very suitable areas, which are mostly in the central (old army barracks), southern (upstream lands of the Mantagheh barracks, Maleksh and Takhte Arkan), southwestern (old police station) and southeastern parts (Hamzanlu, Kalateh Yavarie and Farhangian town) in the research area. Therefore, considering the current area of Bojnourd, there is an optimal development space for the coming years based on moving in a low-risk path. The present study is based on a systemic approach and the application of geomorphological restricted areas and the research results for space management have the residential development efficiency for urban and suburban areas.

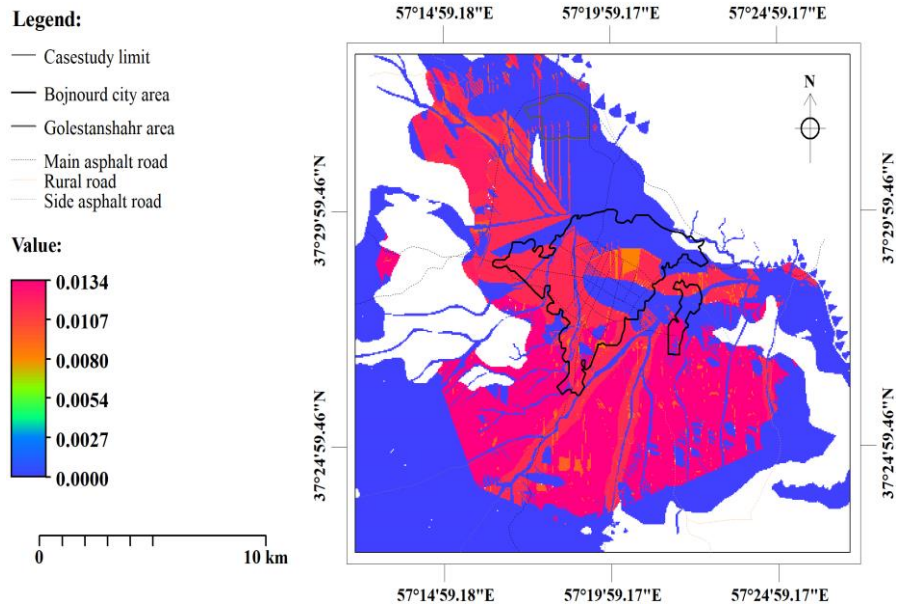


**Figure 2. Map of forbidden areas and prospects for residential development in research area**

**Keywords:** Urban Geomorphology, Geomorphological Restricted Areas, Urban Development, Natural Hazards, Bojnourd.

# Providing a model for implementing and promoting safety culture in project-oriented construction organizations in order to reduce the risks of the construction industry

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## Introduction

Accidents not only cause serious losses but are also a detrimental influence on society. Hence, safety is one of the critical problems facing the sustainable, rapid, and healthy development of the national economy and social stability [21]. Construction-related accidents not only result in workers' deaths and injuries but also cause financial losses due to delays in projects, damage to machinery, and harm to firms' reputation [13]. The almost declining accident rate indicates that safety development has had a significant impact on safety performance in the manufacturing industry. However, in recent years, it seems that this progress has reached a steady state and the industry is facing difficulties in achieving further progress [9, 16]. The construction sector has a large contribution to the economy [14] and is known as a hazardous industry worldwide [15]. Construction industry has one of the highest rates of fatalities and injuries compared to other industries, despite technological advancements and implementations of occupational health and safety initiatives [2]. According to the reports, construction industry has the highest accident rates of all industries, and is the site of the most serious accidents in terms of severity of injuries [11]. Construction safety has always been a major issue and has a reputation as the most dangerous sector with increased rates of accidents and deaths compared to other sectors [12]. In the USA, around 21.1% of fatal accidents occur in the construction industry [20], which only has 8.5% of the country's total employment [17]. In the UK, fatalities in the construction industry in 2017 were higher than the average of fatalities in all industries [10]. In Singapore, around 29% of the workforce is in the construction industry but 40% of occupational accidents occur in this industry [6].

Over the past few years, the role that safety culture or safety climate plays in shaping safe environments has been increasingly recognized by organizations in high-risk industries. Many high reliability industries around the world has been

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showing an interest in the concept of ‘safety culture’, as a way of reducing the potential for large-scale disasters [8].

The International Atomic Energy Agency first used the term safety culture during the investigation of the Chernobyl accident, which was attributed to a weak safety culture [7].

According to Cooper, safety culture is a subset of organizational culture that affects the attitude and behavior related to the safety of members of the organization. The commonality in the numerous definitions is that they can all be grouped into normative beliefs perspective, as far as each is focused on different degrees on the way people think and/or behave in relation to safety [18].

The UK Health and Safety Commission defines safety culture as: the safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determines the commitment, style and skill, health of the organization and safety management. Safety culture refers to the core beliefs and values of a group of people regarding risk and safety [4]. Improving attitudes and creating new beliefs and behaviors in the mind can greatly reduce the damage and increase safety [1].

**construction safety culture**

Construction safety culture can be defined as an assembly of individual and group beliefs, norms, attitudes and technical practices that are concerned with minimizing safety risks and exposure of workers and the public to unsafe acts and conditions in the construction environment [22]. According to the main features of construction projects such as management activity, construction process, temporary project team, environmental issues and site management activity, construction project safety culture should be different from the organization safety culture in terms of scope and components. The construction project safety culture is defined as a combination of attitudes, beliefs, values, behaviors and norms of individuals and groups from different parts of the construction project team (both workers and management) and is gradually formed in the construction project environment and develops, which affects the commitment, style and efficiency of how all departments and individuals in the project behave and react, in terms of existing safety performance. The construction safety culture is born with the creation of the project team and usually develops gradually through inputs from the three sections of trends, beliefs, values and behaviors from the perspective of management and the workforce [5]. Figure 1 shows the construction safety culture model.

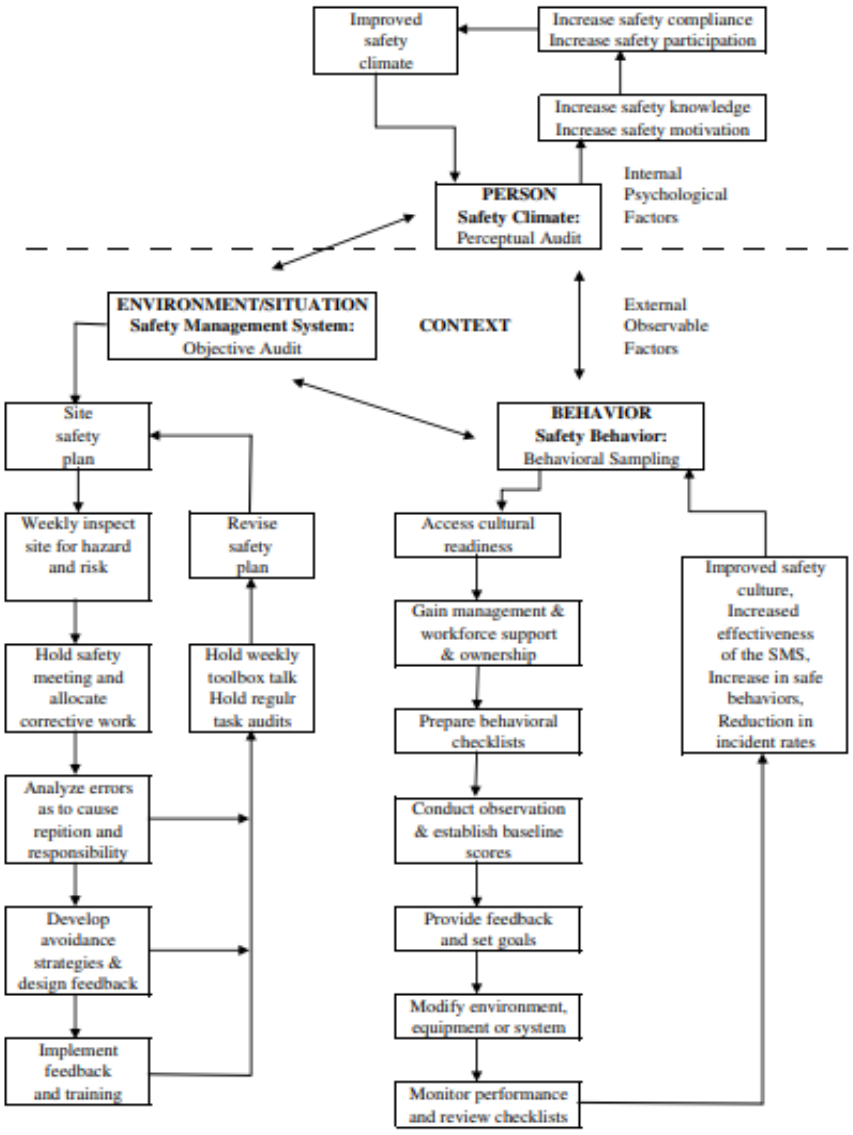


**Fig. 1. Model of construction safety culture [1]**

**building a safety culture**

Any process that brings together all levels within an organization with a view to working together to achieve a common goal that everyone holds in high value will strengthen the organizational culture. Health and safety at work is a unique area of management activity that can achieve this end [19].

The process of building a safety culture incorporates many elements. Some of the more important elements are outlined below [19].

- **Obtaining senior management commitment**. This is the fundamental first step in the exercise and may involve a presentation at a board meeting to obtain their approval and commitment. They must be advised of the need for change and their support for such change. It may be appropriate to give an indication of current direct and indirect costs to the organization associated with, emphasizing the fact that the reduction in these costs should more than pay for the changes required. This requires a commitment from senior management on an ongoing basis.
- **Building trust.** To accept change, people need to have trust. Trust will occur and increase as different levels within the organization work together and begin to see success.
- **Self-assessments or benchmarking techniques.** The person running the scheme, such as a health and safety practitioner will need to keep track, through self-assessment and techniques like benchmarking, to ensure he is being effective in stimulating progress by managers.
- **Management training.** All levels of management, employee representatives, health and safety committee members and employees will need some level of training, not only in areas such as hazard recognition, legal requirements and safety procedures, but also in communication and team building.
- **Steering committee.** A Health and Safety Steering Committee, initially chaired by a director or senior manager, and comprising management, employee representatives and specialists, such as a chief engineer, should be established. The senior health and safety specialist should act as secretary and organize the committee. This committee will provide guidance and direction and avoid duplication of effort. Fundamentally, the committee should have specific authority to get things done.
- **A shared vision.** This is one of the most important features of a safety culture where everyone in the organization shares the same ambitions and feelings about the need to improve safety performance by following the policies, procedures and systems being promoted.
- **Role definition.** The role and function of everyone from the top of the organization downwards should be defined and specified.
- **Accountability.** A system identifying individual accountability for health and safety should be introduced. This may incorporate job safety specifications for different groups of workers. Specific groups may need training to meet the requirements of job safety specifications.
- **Feedback**. As with any system designed to bring about change, there must be feedback which gives a clear indication as to how change is proceeding. Feedback should not necessarily take the form of reduced

accident and sickness rates as these are not a true measure of performance and are open to manipulation.

- **Policies for recognition.** Recognition of success by departments, sections and by individuals should feature strongly in the process. Success in achieving health- and safety-related objectives should receive publicity within the organization and recognized by the awarding of trophies at ceremonies laid on for this purpose. The public recognition of high standards of health and safety through the establishment of awards adds credence to the whole process.
- **Awareness training and commencement.** Everyone should be trained in the purpose of the programme, health and safety awareness and the means for measuring performance. The commencement of the scheme should receive high levels of publicity seeking the commitment of everyone to the improvements.
- **Process changes.** Recommended changes arising from the various activities involved should be implemented promptly. Failure to do so results in loss of credibility of the scheme.
- **Performance measurement.** There should be continual measurement of performance and reporting back to the steering committee.
- **Communicating the results.** Results should be communicated through posters, notice boards and newsletters: progress reports should be discussed at departmental meetings.
- **Reinforcement and reassessment.** As with any scheme, there is a need for regular reinforcement, feedback, corrections to the system and reassessment of specific features.

## Materials and methods

The information of this research can be seen in the following table:

**Table 1. Research information**

| | |
|---|---|
| research type | Qualitatively- Applied |
| Research Method | Grounded theory |
| research model | Conceptual |
| Data collection tools | Library studies- semi-structured interview. |
| Research population | Interviews with consulting companies and contractors |
| Research area | Construction project based organizations |
| Sampling | snowball |

The main data collection tools in this study are:

- Library studies;
- semi-structured interview.

In this research, semi-structured interview method is used. In this research, experts were interviewed with different positions (CEO, Project Manager, Safety Manager, Contractor) in order to extract the desired challenges from different perspectives.

**Table 2. Semi-structured interview questions [author].**

| |
|---|
| 1- In your opinion, what indicators are needed to achieve safety culture in order to achieve performance excellence in safety? |
| 2- Do you consider the development of a safety strategy as a necessary indicator of a safety culture? If yes, what components do you think the organization needs to create a safety strategy? |
| 3- Do you consider the assessment of the existing safety culture of the organization necessary to promote the safety culture? If yes, what tools and methods can be used to make this assessment? |
| 4- Do you think a clarity is effective in advancing the goals of a safety culture? If yes, how can this be achieved? |
| 5- In your opinion, does the path of safety culture pass through the safety climate? If yes, how can a proper safety climate be created in the organization?<br>6- In your opinion, what factors affect the safety climate in the organization? |
| 7- What are the appropriate elements to maximize the true potential of a safety culture for excellence in the organization? |
| 8- Do you think that identifying, prioritizing, and addressing safety challenges play a role in developing a safety culture? If yes, how can it be controlled? |
| 9- How can continuous improvement in safety culture be achieved? |

## Research data

Indicators and sub-indicators affecting the safety culture extracted from the literature and interview are:

**Table 3. Cultural safety indicators and sub-indicators [Author].**

| Indicators extracted from the interview | Indicators extracted from the literature |
|---|---|
| | **1- Development of safety strategy** |
| | • Purpose<br>• Core values<br>• Vision<br>• Long and Short-Term goals<br>• Objectives<br>• Marketing<br>• Initiatives<br>• Safety Excellence Accountability system<br>• Identify and enable change agents<br>• Measure/adjust<br>• Continuous Improvement |
| | **2- Assessment of existing safety culture of the organization** |
| • Interviews<br>• Safety Data Analysis | • Evaluation of Existing Safety Initiatives<br>• Perceptions |
| | **3- Clear understanding of safety (Clarity)** |
| • safety excellence team clarity | • safety excellence team structure |

| | |
|---|---|
| workshop | • safety excellence team strategy briefing<br>• steps employee briefing(s) |
| | **4- Safety climate** |
| | • Commitment<br>• Caring<br>• Cooperation<br>• Coaching |
| | **5- Create the right safety structure and composition (chemistry)** |
| • proactive accountability<br>• vulnerability | • Passion<br>• Focus<br>• Expectations<br>• Reinforcement<br>• Communication<br>• Measurement<br>• Trust (The Bonding Agent) |
| | **6- Control** |
| • motivation | • targeting safety improvement<br>• taking a safety-improvement step<br>• converting BBS to STEPS |
| | **7- Continuous improvement** |
| • multilevel support<br>• new-employee orientation to STEPS | • ongoing safety-improvement STEPS<br>• focus, influence, listen , measure for a cultural snapshot<br>• succession plan for safety excellence team<br>• professional development<br>• reassessment |

## Discus and Results

The most comprehensive way to move forward in order to achieve a safety culture is to learn steps called strategic target for excellent performance in safety (Figure 2).

If leaders decide to go with the steps (strategic target for excellent performance in safety), they must move forward. Each set of steps leads to an organizational milestone. In the following, will see the model proposed for implementing and promoting a safety culture for excellence (Figure 3).

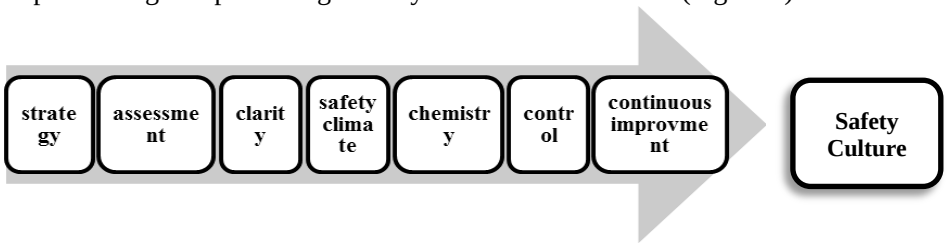


**Fig. 2. Milestones in the path of the steps [author]**

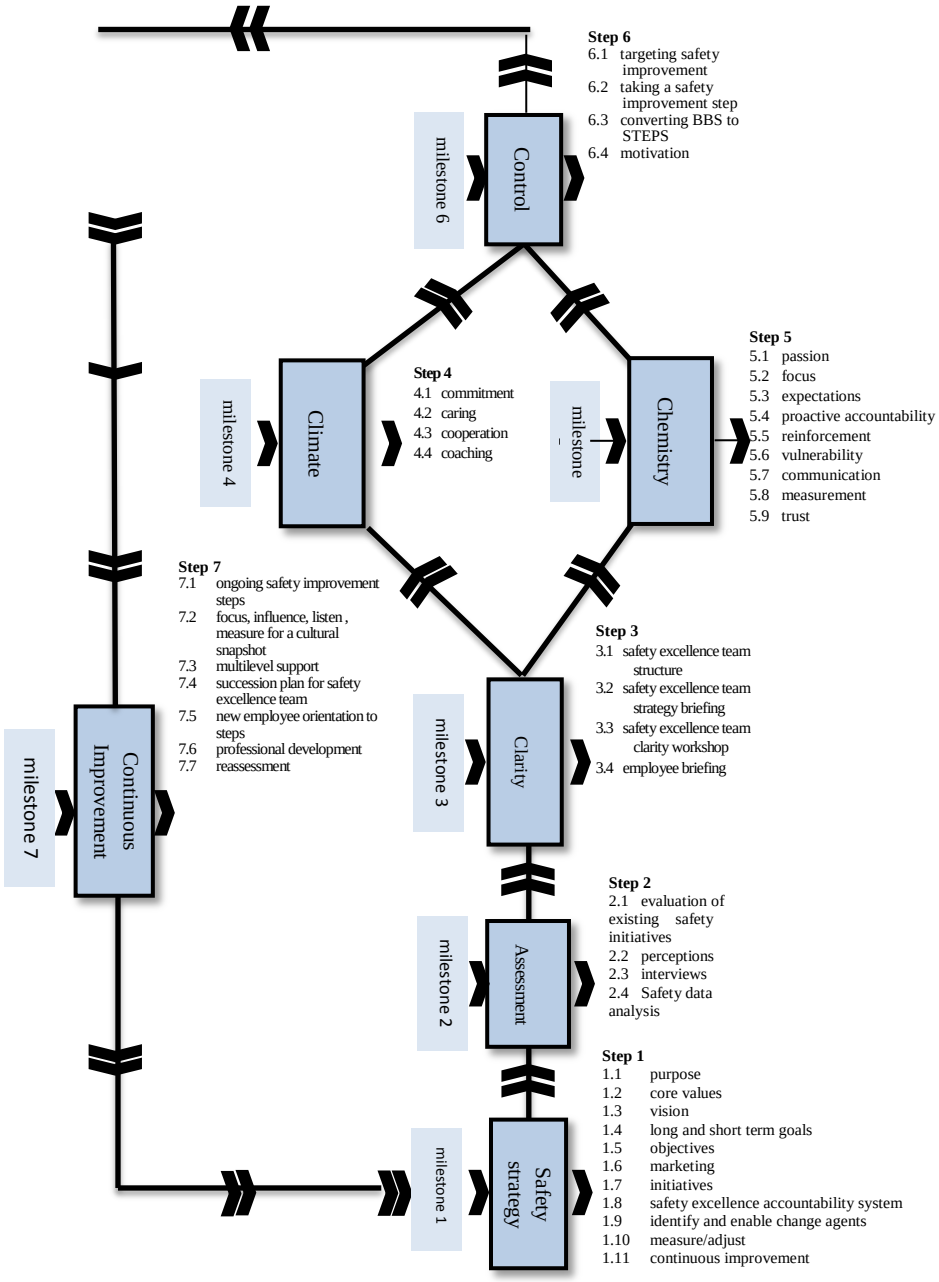


**Fig. 3. Safety culture promotion model [author]**

**Proposed executive solutions to improve the level of safety culture in construction project-oriented companies**

**Have a safety strategy.** It is impossible to set a strategic target if you do not have a strategy. Most organizations, frankly, do not have a safety strategy. They have goals, wishes, programs, and metrics, but all these do not really have a framework that brings them together. An effective strategy can help focus on the right, measurable goals of achieving excellence rather than avoiding failure.

**Objectives of Step 1:**

- To move from avoiding failure to achieving success
- To include excellence in the safety vocabulary
- To align all safety activities around an overarching strategy
- To provide a clear and repeatable direction toward success
- To align and motivate workplace behaviors to accomplish the strategic goals

**Methods of developing a safety strategy:**

- A leadership training and workshop or multiple workshops to develop a Safety Strategy

**Perform an assessment of your starting place.** Determine what kind of safety culture you already have, what strengths can be utilized, and what additional capabilities it needs to improve. Understand your starting point and use it as a baseline to measure further improvement.

**Objectives of Step 2:**

- To understand and appreciate the current status of your safety culture
- To determine what is currently influencing the culture
- To evaluate existing safety teams or committees for possible use in STEPS
- To evaluate existing safety programs for possible improvements
- To establish a baseline for measuring progress

**Methods of assessing:**

- Evaluation of existing safety programs
- Perception survey
- Interviews with individuals and focus groups
- Pareto analysis of safety data

**1. Create clarity of purpose.** Deploy your safety strategy, organize and train the members of the culture at every level in the strategy to learn the basic definitions of safety and the improvements needed. Especially teach the culture the basic skill of targeting and accomplishing what we call STEPS. Share the rationale for improvement, how the organization will benefit .Structure a safety excellence team to steer the organization through the STEPS.

**Objectives of Step 3:**

- To designate or establish a safety excellence team to steer the STEPS process
- To set clear expectations about the what and how and why of STEPS
- To align thinking about safety (get everyone on the same page)
- To define crucial terminology and methodology
- To begin to market the safety-excellence journey

**Methods of clarity:**

- Evaluation of existing safety committee and/or formulation of a new one
- Training
- Workshop
- Workforce briefing

**1. Create the right safety climate.** Create or improve the organizational climate in which a safety culture can grow into its personal best.

**Objectives of Step 4:**

- To create a commitment to safety excellence
- To drive the safety efforts by caring about each other
- To establish a basis and encouragement for cooperative efforts among the various levels
- To establish coaching as the method of helping each other to improve performance
- To train everyone in the skills of coaching safety
- To create an environment conducive to growing an excellent safety culture

**Methods of creating a safety climate:**

- Safety excellence team workshop
- Declaring commitment to safety excellence
- Changing the aim of safety from statistics to people
- Creating forums and communication tools to encourage cooperation
- Training

**1. Create the right safety chemistry.** Make sure that the culture has the elements necessary for safety excellence growth and that these elements are renewed as they are utilized.

**Objectives of Step 5:**

- To convince everyone that accidents can happen to them
- To set realistic expectations about how to get to excellence
- To teach the culture how to focus on the right issues and to prioritize them
- To make sure that the desired actions are positively reinforced

- To improve the model and media of safety communications
- To develop a strategy for motivating the journey to safety excellence

**Methods of creating a safety chemistry:**

- Training
- Workshop

1. Create the control to address the issues of conditions and common practice that impact safety. Prioritize and address your safety issues one at a time.

**Objectives of Step 6:**

- To enhance the culture's ability to identify risks
- To enhance the culture's ability to prioritize risks for maximum effectiveness
- To teach the safety excellence team to develop action plans to address risks
- To help the safety excellence team to communicate ongoing action plans
- To help the safety excellence team to communicate progress toward success of action plans
- To align behavior-based safety (BBS) with STEPS
- To align safety motivational strategies with the success of action plans

**Methods of control:**

- Accident-investigation data analysis
- Pareto analysis
- Developing action plans
- Communicating action plan details and progress metrics

**1. Your safety culture can now continuously improve safety.** Reassess, measure, and adjust-recognize progress and barriers and react appropriately and flexibly to meet the changing needs.

**Objectives of Step 7:**

- To set clear expectations about continuous improvement, STEP by STEP
- To align levels of the organization in support activities
- To establish a rotation plan for the safety excellence team
- To establish a new-employee orientation to STEPS
- To identify professional development activities for the safety excellence team and cultural leaders
- To provide guidelines for execution of the safety strategy
- To recommend ongoing assessments to identify improvement opportunities

**Methods of continuously improve:**

- Evaluation
- Action plans to address problems or opportunities to improve
- Attending events or obtaining professional development materials

## Conclusion

Plan your organization for the real movement in the direction of safety culture. It helps to have the entire roadmap in your mind before you begin. It also helps to fully appreciate what will be required as you prepare to inform others and to help them make the commitment to pursue safety culture excellence.

The order in which we have arranged the STEPS has come from a lot of experience. If you are planning to visit each step, please do so in order. As you move to a new STEP, please assess your status in that area of performance. Skip over any STEPS that you have already addressed and simply review them to see if you find ideas to further improve.

Remember that this model is not a complete formula; it is more of a framework from which to make strategic decisions. Organizations are so unique that no formula for improvement is universally applicable. The closest to a universal truth is the fact that the more you customize this process to your organization, the better it will work. Also, as you assess where your current safety performance is weak and where it needs help, do not forget to look for your strengths and build upon them.

**Keywords:** safety culture, safety climate, safety performance, construction industry, safety culture model.

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