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## Improving decision making by using hazard analysis model for the city of Jeddah, Saudi Arabia

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### Key words

Hazard Analysis Model; Jeddah Municipality; Risk Index

### Abstract

The aim of this paper is improve Jeddah Municipality effectiveness and efficiency through using risk index based methodology in decision making in order to develop strategies, policies, and plans to deal with city issues and problems. Risks were prioritized according to their significance in terms of likelihood, consequences, and effects in light of municipality's stakeholders. It is found that real estate market control by expatriate, increasing in traffic accidents, the presence of factories and workshops in the residential areas, and abandoned buildings, as well as proliferation of street vendors were the most hazards that of importance to city's stakeholders.

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### Introduction

The city of Jeddah on the west coast of the Kingdom of Saudi Arabia in the middle of the Red Sea with a total area of 748 km<sup>2</sup> is one of the most important cities in Saudi Arabia and the gateway to trade, which has gained great importance the movement of international trade with foreign markets. Jeddah is characterized as a main gate of the Two Holy Mosques and the first stop for the pilgrims and pilgrims coming to the leading of the Holy Land (Mecca and Medina) enters through the year to Jeddah's King Abdul Aziz International large numbers, up to 5 million people annually with the purpose of Hajj or Umrah or study or tourism and entertainment (Momani and Fadil, 2010).

The growth of the city to become one of the largest ones in Saudi Arabia which is considered to be the financial capital of the country. Jeddah is of the earliest historical cities and has gained its position through the ages from its geographical location as a gateway to the holy places Mecca and Madina. After that Jeddah lives in the process of urbanization since 1980, starting with area surrounded with a wall that has two doors on the Mecca and the other from the sea area with approximately one km<sup>2</sup>. According to the first local urban planning of the city of Jeddah in 1962 the area of Jeddah was 700 km<sup>2</sup> and in another urban plan in 2006 the area became about 2350 km<sup>2</sup> with noting that the total area of Jeddah is 5000 km<sup>2</sup> with population of more than three and a half million people in 2012. This enlargement of the city make it difficult to handle city issues and problems (hazards) at the same time to please different stakeholders such as government officials, investors, residents, visitors and others due to different hazards. Therefore, we suggested a framework to develop weighting criteria that could be used in setting

future plans, policies, procedures that could consider city priorities from different stakeholders' perspectives.

In order to improve decision making for land development affecting infrastructure system, Thekdi and Lambert (2012) developed a layering and coordination of models for risk management of land development affecting infrastructure systems. These layers are: system identification, expert elicitation, predictive modeling, comparison of investment alternatives, and implications of current decisions for future options. The approach integrates to a decision framework of strategic considerations based on assessing risk, cost, and opportunity in order to prioritize needs and potential remedies that mitigate impacts of land development to the infrastructure systems.

As for product development, Jiang and Pan (2012) proposed a method for selecting new product development programs regarding risk attitude of decision makers. Khazaeni et al. (2012) proposed a fuzzy adaptive decision making model for selection of balanced risk allocation which transforms the linguistic principles and experiential expert knowledge into a more usable and systematic quantitative-based analysis by using the fuzzy logic. Additionally, Chang and Wu (2012) elaborated on the consequences of perceived risk by taking the moderating effects of decision-making style (i.e., involvement vs. heuristics) into account in the context of online shopping.

Gregory et al. (2012) examined opportunities for seismic risk mitigation decisions at U.S. maritime ports, with special reference to the role of stakeholders and the quality of the decision-making processes used to inform seismic risk initiatives. It is concluded that increased attention to the quality of stakeholder input is likely to improve port seismic risk-management decision processes. When attempting to quantify risk, a number of problems arise in the public sector where multiple stakeholders are involved.

Pate-Cornell (2002) proposed approaches to the treatments of uncertainties in risk analysis, their implications for risk ranking, and the role of risk analysis results in the context of a safety decision process. Moreover, he discussed the implications of adopting conservative hypotheses before proceeding to what is, in essence, a conditional uncertainty analysis, with considering different levels of "conservatism" for the ranking of risk mitigation measures. Public's risk perception should be considered as input into political and administrative decision making. Sjoberg (2001) proposed several arguments if we should let the experts run risk policy and discussed the weaknesses of risk perception models.

This paper presents literature review of risk decision making models and proposes a methodology that could be used for city of Jeddah and other comparable ones.

## **Methodology**

This paper suggests a decision making model to improve Jeddah Municipality effectiveness and efficiency in utilizing existing resources through prioritizing city issues and problems (hazards) through using risk index based methodology in decision making. The

research methodology which is used in this paper consists of conducting seven community based workshops to solicit community hazards- more details about the workshops will be discussed latter in this paper- designing questionnaire based on these workshops that cover all mentioned hazards, survey of stakeholders' feedback, a statistical analysis of the survey data, and ranking of identified risks from the perspectives of stakeholders.

The questionnaire consisted of two sections. Section I solicited general information about the respondents. Section II consists of 57 hazards associated with city of Jeddah perspective and asked respondents to review and indicate the likelihood of occurrences of these hazards as: highly likely, likely, less likely. Also, participants were asked to identify the selected risk magnitude of consequences for the city as: high, medium, and low. Finally, section II asked respondents to indicate the potential effects of selected risk as: environmental, economical, security, social, and political. These hazards were sourced from different workshops that have been conducted through representative districts in Jeddah such as shown in Table (1) and a list of residents' complains that have been taken from Jeddah Municipality hot line number 940 departments. This hot line free number enable residents to call and register their complains. We included the hazards which accumulate 85% of the entire registered complains for one year, as shown in Table (2).

Table (1): Key risks as per their significance from Jeddah districts as pointed out through seven community workshops

District	Location/ Municipality	Date	No. of participants	Main issues and problems (hazards)
1st	Southern Municipality	6/3/2012	40	Groundwater in the area east of the highway, building heights, pollution, quarries, factories nearby, illegal workers.
2nd	Om Alsalam Municipality	11/3/2012	15	The spread of rodents collapses asphalt, low level of hygiene, the spread of odors, affected residents of the multiplicity of roles.
3rd	Azizia Municipality	13/3/2012	75	Creation of parks and public spaces for young people, finding practical solutions to traffic bottlenecks, find quick solutions to expedite the issuance of building permits, car wash in the streets and the spread of workshops within the neighborhoods.
4th	New Jeddah Municipality	19/2/2012	13	Bulk of employment, random buildings, compensation of developed areas in Ruwais, hygiene, lack of parks, lighting.
5th	Matar Municipality	4/3/2012	25	Unification of paintings for shops, hygiene, lighting, historical development of the region, the roles of mayors.
6th	Al Balad Municipality	14/2/2012	90	Ground water in front of homes and schools, non-delivery of electricity for homes, hygiene, bulk of employment, the lack of instruments to some of the workers.
7th	Briman Municipality	12/2/2012	45	Burning of tires in the south of Jeddah, discharge water and sanitation in riverbed, mosquito breeding, infrastructure, traffic congestion.

Table (2)

Key risks as per the Jeddah Municipality hotline 940 number

Issues and Problems (hazards)	Total Complains	% of Total Complains
The spread of mosquitoes	1311	12
Spread of smell of sewage	1092	10
Others	1017	10
Accumulation if household waste	895	8
The lack of lighting	888	8
Street pavement	723	7
Worn out asphalt layers	463	4
Prevalence rodents	378	4
Absence of lightning columns	365	3
Asking for Jeddah Municipality representative	338	3
lightning column is not working	212	2
Absence of waste containers	190	2
low level if cleanliness of restaurants and shops	179	2
Not pavement streets after excavation ends	163	2
Personnel selling	155	1
Asking for ambulance	137	1
Worn out asphalt layers	120	1
The presence of damaged and abandoned vehicles	116	1
High water table	108	1
Street pavement	112	1
Total	8962	85

During each workshop Jeddah Municipality City Council were invited to listen to stakeholders for that part of the city which consists of different districts, as shown in Figure (1), in order to identify the main problems along with potential quick solutions given that Jeddah Mayor assistant has attended all workshops. Among stockholders were: City officials, elected member in the city council, investors, residents and others.

After conducting the seven workshops it was difficult to prioritize community needs to identify strategies, plans, policies, and procedures that are needed to overcome such hazards. Therefore, we developed risk based decision making model which consider different stakeholders' input as we have discussed above. The questionnaires were distributed to 250 stakeholders in Jeddah City. 148 responses were received which represents a response rate of 60%.



Figure 1 Jeddah City Districts

### Sample Composition

The respondents have been selected to represent different views for Jeddah City districts. More details of the respondent profiles are presented in Table (3). The respondents' different perspectives in selecting potential hazards for Jeddah City such as potential effects, magnitude, and consequences base our model on realistic expectations that will help in future risk management planning. As shown in Table (3) 44% of our sample holds bachelor's degree and only 8% percent below high school. Also, 40% of our sample has more than 5 years of experience with their tested area which enable them to give better appreciation with the problems that their area face and about 18% of our sample has less than a year with the tested area which could help them to spot new issues or unusual ones that the other part of sample could realize due to their living experiences. In our sample, we took all the elected members within the city council and part of the municipality employee. Most of the sample, 32%, was among resident within that tested area. In our sample we tried to have representation from all district to be able to prioritize different issues and hazard on the city level.

Table (3): Profile of the survey respondents

Respondents Profile	Categorization and percentages			
Educational background	Below high school (8%)		Bachelor's degree(44%) Doctoral degree (5%)	
	High school (36%)	Master's degree (7%)		
Years of experience in the area	More than 5 years (40%)	1-5 years (42%)		Less than a year (18%)
Reasons of interest	Elected member (5%)	Municipality mayor (3%)	Resident (32%)	Other (3%)
	Investor (7%)	Municipality employee (20%)	Interested in the area (30%)	
District	1 <sup>st</sup> (16%)	2 <sup>nd</sup> (14%)	3 <sup>rd</sup> (14%) 4 <sup>th</sup> (15%) 5 <sup>th</sup> (12%)	6 <sup>th</sup> (16%) 7 <sup>th</sup> (13%)

## Data Analysis Method

The survey feedback includes three groups of data: The likelihood of occurrences of each risk, and its magnitude of consequences, as well as potential effects in terms of environmental, security, social, economical, and political ones. The three point scales for the likelihood  $\alpha$  (highly likely, likely, less likely) and the consequences  $\beta$  (high magnitude, medium magnitude, low magnitude) and the potential effects  $\gamma$  (environment, security, social, economical, and political). These point scales need to be converted into numerical scales. Zou et al. (2007) used a value of 1 for high, 0.5 for medium, and 0.1 for low which were also used in this research. As for the potential effects scale we consider that all effects to have the same weight given that the maximum potential effects could reach 100% so each effect will contribute 20% of the total effects. This scale which is used to identify  $\alpha$ ,  $\beta$ ,  $\gamma$  values could be modified when there is rational, i.e. if social issues are less important than economical issues it will take less weight than the suggested ones. The risk index for each hazard is calculated through Eq. (1)

$$r_{ij} = \alpha_{ij} \beta_{ij} \gamma_{ij} \text{Eq(1)}$$

Where  $r_{ij}$ = Significance score assessed by respondent  $j$  for the impact of risk  $i$ ,  $i$ = ordinal number of risk,  $i \in (1, m)$ ;  $m$ = total number of risks;  $j$ = ordinal number of valid feedback to risk  $i$ ,  $j \in (1, n)$ ;  $n$ = total number of valid feedbacks to risk  $i$ ;  $\alpha_{ij}$ =likelihood of occurrence of risk  $i$ , assessed by respondent  $j$ ;  $\beta_{ij}$ =consequence of risk  $i$  assessed by respondent  $j$ ,  $\gamma_{ij}$ = potential effects of risk  $i$  assessed by respondent  $j$ .

The average score for each risk considering its significance from the perspective of stakeholders can be calculated through Eq. (2). This average score is called the risk significance index score which will be used to rank among all hazards.

$$R_i = \frac{\sum_{j=1}^n r_{ij}}{n} = \frac{1}{n} \sum_{j=1}^n \alpha_{ij} \beta_{ij} \gamma_{ij} \text{Eq(2)}$$

Where  $R_i$ = significance index score for hazard  $i$ . Risks are ranked in accordance with their significance index ( $R_i$ ) for the study area that are based on different viewpoint from stakeholders such as citizens, investors, government officials, elected member, municipality workers. It is important to mention that the hazards which have been identified in this study have been taken from stakeholders' perspective and not from scientific findings. For instance, Momani and Fadil (2010) discussed the last flood disaster which occurred in Jeddah City in 25th of November 2009 which caused more than 121 fatalities and billions of dollars in losses in addition to around 20,000 sheltered families which cause a shift in public policy to deal with natural disasters in Saudi Arabia. In this study natural causes and human errors and lack of clear public policy to deal with natural disasters were the most contributors to human and monetary losses due to the flood disaster. Since such natural and man-made disasters need to have experts involvement in a given hazard more than stakeholders involvement. There are different models which have been developed to measure potential consequences from a given hazard such as ECM model and the Integrated Framework for Earthquake Consequences Management which were developed by Naill Momani (2009, 2012 respectively). These models could be used along with our suggested model in order to have better understanding of natural

and man-made hazards for the study area which enable rational decision making to prevent and/or reduce human and monetary losses.

### Survey Results and Analysis

The purpose of this paper is to help Jeddah City Council in prioritizing their plans and activities to solve community raised problems which will maximize utilizing the city resources. Decision making priorities based on risk significance index will show stakeholder that decision made by the City Council consider their risk significance perspective. The result of the ranking is presented in Table (4) for the hazards which get score more than 0.17. For other risk see Appendix A.

Table (4): Hazards ranking for city of Jeddah

Key Hazards	Acronyms	Risk Score	Index
The spread of random buildings in the region	SRBR	0.28	
Real estate market control by expatriate	RMCE	0.25	
Increase in traffic accidents	ITA	0.25	
The presence of factories and workshops in the residential area	PFWR	0.24	
Abandoned buildings and backyard for a long time	ABLT	0.23	
Labor housing in the neighborhood	PSV	0.23	
Proliferation of street vendors	LSV	0.23	
Lack of sewerage network	LSN	0.23	
Disparity in the prices of goods	DPG	0.22	
Accumulation of rain water	ARW	0.22	
Rash groundwater	RG	0.22	
Traffic congestion	TC	0.22	
Low level of cleanliness of restaurants and shops	LCRS	0.22	
Accumulation of household waste	AHW	0.21	
Cartons and paper stored in an abandoned backyard	CPSB	0.21	
Streets pavement	SP	0.21	
Emptying sanitation in riverbed	ESR	0.20	
The presence of damaged and abandoned vehicles	PDAV	0.20	
Asphalting the streets is not good	ASG	0.20	
Compensation owning property is a fair	COPF	0.20	
Worn out asphalt layers	WAL	0.20	
Waste was randomly burned	WRB	0.19	
Spread the smell of sewage	SSS	0.19	
The absence of a signal light at the intersections	ASLI	0.19	
Car wash in the informal neighborhoods	CWIN	0.19	
Coordination is not good for government projects in the neighborhood	CGPN	0.19	
The spread of mosquitoes	SM	0.19	

Indiscriminate burning of tires	IBT	0.19
Loop vegetables in neighborhoods	LVN	0.18
Non-asphalt paving roads	NPR	0.18
Rehabilitation of public parks	RPP	0.18
Landfill waste gases in the region	LWGR	0.18
The lack of lighting columns	LLC	0.18
Lack of accountability in the errors of the engineering projects	LAEP	0.18
Irregular burning of the waste	IBW	0.17
The spread of dust crushers	SDC	0.17
The absence of sufficient schools	ASS	0.17
Riverbed is not clean	RC	0.17
Illegal Crossing streets by pedestrians	ICSP	0.17
Disable projects from building permits delay	DPD	0.17
Not to expand in the community centers of neighborhoods	ECN	0.17
Road accidents in the neighborhood	RAN	0.17

## Discussion

Jeddah is of the earliest historical cities and some believe that the tomb of Eve is there. Jeddah has gained its position through the ages from its geographical location as a gateway to the holy places Mecca and Madina. After that Jeddah lives in the process of urbanization since 1980, starting with area surrounded with a wall that has two doors on the Mecca and the other from the sea area with approximately one square kilometer. Having an airport for the city was a sign for an urbanization for any modern city that is why an airport was established in the north of Jeddah city far from the construction, which contributed to the expansion of the city of Jeddah through planning and the spread of random buildings in the region (SRBR) in areas between the airport and the old city. According to the first local urban planning of the city of Jeddah in 1962 the area of Jeddah was 700 km<sup>2</sup> and in another urban plan in 2006 the area became about 2350 km<sup>2</sup> with noting that the total area of Jeddah is 5000 km<sup>2</sup> with population of more than three and a half million people in 2012.

The organization within the urban wall and outside the wall were considered areas not belonging to the organization and planning was so spontaneous, which led to the emergence of SRBR with a total of more than 53 areas out of about the 119 neighborhood where it is possible that a residential neighborhood contains more than one region SRBR i.e. not subject to the regulation of urban planning worsening the problem of its proliferation as shown in the results of the study. Due to the presence of SRBR and the spontaneous planning to the city of Jeddah there is no adequate way and safe corridors for vehicles and pedestrians. Moreover, there is a lack of public transport for instance in a workshop for the province it became clear that private transport accounts for 96% of the total transport in the city, noted that international standards are very different given that the rest of the cities which are similar to the city of Jeddah has public transport such as trains and mass transit, which led to traffic jams and increase in traffic accidents. Additionally, large proportion of young people want to own a private car other than



the family car, especially down the cost of oil and coincided with the lack of traffic awareness and commitment transport systems contributed to the increase of traffic accidents and the worsening of the crisis.

As for the problem of Abandoned buildings and backyard for a long time it was due to providing better services in new neighborhoods and the desire to get out of the crowded downtown area with having the purchasing power that are looking for what is trendy and sophisticated contributed to the migration from the old quarters to new neighborhoods, making navigation residential from region to region is one of the unwanted habits. This resulted in the migration of historical and old areas, without maintenance and attention and their migration to the new ones. The lack of historical building system in place for the maintenance of abandoned buildings has contributed to the spread of this phenomenon, which resulted in security problems and areas harboring random segments of illegal workers violating homeland security issues.

SRBR and the migration of old buildings by the citizens and the openness of the Saudi society due to visitors to the holy places and an abundance of purchasing power in addition to the high rate of per capita income contributed to the proliferation of street vendors who are mostly have no valid visas to the country. Such people have no other means of subsistence but only those simple actions to create daily income in the absence of control and cheap prices submitted by them due to the absence of costs in the establishment of shops, which contributed to the popularity and spread of street vendors in the revival of Jeddah. Moreover, the absence of cooperative societies that serve the areas of Jeddah which could provide goods the same as what the street vendors could provide at a competitive prices worsen this hazard issue. Finally, the city of Jeddah is large and it is difficult to navigate easily to get what is provided by the vendors from the daily requirement of basic materials expanded the hazard to the entire city. The different values of the lease between the different areas of the city of Jeddah in addition to the cost of transport contributed to the varying prices of goods in the city of Jeddah as mentioned earlier. The residents of the city of Jeddah began to be affected by the modern style of living, making merchant offers item a different way from traditional methods to meet the needs of the consumer segment with high-income rates differ from those in popular areas knowing that the price disparity is a feature of trade in the world. Note that it is possible for the Society for the Protection of Consumer stabilize the prices of basic commodities in different regions through the establishment of cooperative societies as an alternative to commercial markets with high profitability.

That the increase in immigration to the city of Jeddah from the Kingdom and abroad to seek livelihood or closer to the holy places which has increased the need to patch population and where the area of Jeddah, did not exceed square kilometers, as we mentioned earlier and is bordered by mountains to the east and the sea from the West, which facilitated the process of expansion towards the north and west through bridge the large areas of the sea affected by the high water table in addition to the lack of an integrated network of sanitation and the use of cesspits has increased the high water table and cesspits leakage in some areas. To solve the problem of high water table, the government established a company specializing in water to

draw water from some areas to reduce the level of groundwater and contribute to solving the problem of rash groundwater.

The spread of unauthorized employment that are not subject to health screening and surveillance in addition to the lack of sewerage network and the accumulation of waste in the neighborhoods and the lack of awareness of environmental risks has contributed to creating an unhealthy environment that made low level of cleanliness of restaurants and shops. Note that there are institutions concerned with the health of the environment, but are disabled for lack of sufficient human resources to cover more than 2350 square kilometers spread over the coastal strip which is full of restaurants, markets and street vendors. The migration of the old places and the spread of SRBR and the proliferation of street vendors who wish to collect cartons for recycling to benefit from it through the store and re-sale led to the emergence of the focus of the risk of fire and the spread of rodents in abandoned neighborhoods. The lack of a sewage network in the city of Jeddah, and the distance of residential landfill, and the lack of a sufficient number of wastewater treatment plants, and the weak control in a big city, as well as the lack of deterrent for individuals contributed to the disposal of such waste in public parks and places abandoned illegally, causing dangers to the environment.

The rise of underground water in the city of Jeddah and the absence of coordinating committees between stakeholders in the infrastructure to make the streets of the city of Jeddah, the delay of cleaning scene of excavations of third-party service led to the deterioration of asphalt surfaces in addition to the lack of commitment by contractors work the roads world class helped in creating this problem between the period and the other.

### Acknowledgment

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### Appendix. A List of acronyms in order of importance

Key Hazards	Acronyms
The spread of random buildings in the region	SRBR
Real estate market control by expatriate	RMCE
Increase in traffic accidents	ITA
The presence of factories and workshops in the residential area	PFWR
Abandoned buildings and backyard for a long time	ABLT
Labor housing in the neighborhood	PSV
Proliferation of street vendors	LSV
Lack of sewerage network	LSN
Disparity in the prices of goods	DPG
Accumulation of rain water	ARW
Rash groundwater	RG
Traffic congestion	TC

Low level of cleanliness of restaurants and shops	LCRS
Accumulation of household waste	AHW
Cartons and paper stored in an abandoned backyard	CPSB
Streets pavement	SP
Emptying sanitation in riverbed	ESR
The presence of damaged and abandoned vehicles	PDAV
Asphalting the streets is not good	ASG
Compensation owning property is a fair	COPF
Worn out asphalt layers	WAL
Waste was randomly burned	WRB
Spread the smell of sewage	SSS
The absence of a signal light at the intersections	ASLI
Car wash in the informal neighborhoods	CWIN
Coordination is not good for government projects in the neighborhood	CGPN
The spread of mosquitoes	SM
Indiscriminate burning of tires	IBT
Loop vegetables in neighborhoods	LVN
Non-asphalt paving roads	NPR
Rehabilitation of public parks	RPP
Landfill waste gases in the region	LWGR
The lack of lighting columns	LLC
Lack of accountability in the errors of the engineering projects	LAEP
Irregular burning of the waste	IBW
The spread of dust crushers	SDC
The absence of sufficient schools	ASS
Riverbed is not clean	RC
Illegal Crossing streets by pedestrians	ICSP
Disable projects from building permits delay	DPD
Not to expand in the community centers of neighborhoods	ECN
Road accidents in the neighborhood	RAN
The lack of vehicles for street sweeping	LVS
The lack of literary clubs	LLC
Accumulation of abandoned remnants	AAR
Existing of household waste recycling plant	EHWR
High water table	HWT
Prevalence rodents	PR
Prevalence of asthma in the region	PAR
A crusher in the region	CR

Lighting poles not working	LPW
The presence of damaged and abandoned vehicles	PDAV
Environmental risk from the desalination plant	ERDP
Weak presence of security and traffic in the neighborhood	WSTN
Communications towers and its health effects	CTHE
Proliferation of stray dogs	PSD
Lack of sanitation	LS
The presence of high voltage cables	PHVC
Required to increase the No. of permitted stories	RIPS

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