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Strategic Management in Decision Support System for Coastal Flood Management

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ABSTRACT: The management and analysis of flood hazards is of great socio- economic and ecological importance as it was estimated that 50 percent of word's population resides and works within the costal zone till 2030. The management of coastal flood hazard reflects the cumulative effects and criteria more than the human mind can handle effectively. The flood management requires decision making for relatively far and largely unknown parameters and face to the largest uncertainties.This paper aims to provide a quantified method for developed decision making in coastal flood management. It discusses the applying of strategic management in a spatial decision support system (DSS) for analysis and modeling of flood management as important part of integrated coastal zone management (ICZM). This study focuses on flood management in South- west of Iran as case study and use SWOT analysis for gaining to the best result. The main finding of paper is provision of systematic method to choose best strategic alternative in flood management. To reach this target numerical model in multi criteria decision making are developed. The new methodology in this study shows that applying quantitative methods with a combination of DSS and SWOT analysis in flood management can be adopted carefully and helps coastal managers to decrease uncertainties and human errors.

Key words: ICZM, DSS, SWOT Analysis, Strategic Management, Flood Management

INTRODUCTION

Coastal regions have been subjected to numerous studies (Mehrdadi *et al.,* 2007; Kumar and Jayappa, 2009; Priju and Narayana, 2007; Nouri *et al.,* 2008). Flood hazard to the economy, society and the environment reflects the cumulative effects of environmental and socio-economic change over decades. Long-term scenarios are therefore required in order to develop robust and sustainable flood management policies (hall et al, 2004). A considerable global-mean sea-level rise is estimated due to human-induced warming during the 21st century. In the Third Report of Intergovernmental Panel on Climate Change (IPCC) the expected rise from 1990 to 2100 was 9–88 cm with a mid-estimate of 48 cm (Church *et al.,* 2001). Flood risk could be a significant problem if it is ignored, and hence it needs to be considered within the management process and so it is by far one of the most concerns for Coastal managers. The flood management systems play important role in integrated coastal zone management. In the beginning of 1990s it was estimated 21 and 37 percent of the world population lived within 30 and 100 km^2 (Gommes *et al.,*1997). The background of flood management refers to thousands years ago, nevertheless Over the past decade, as scientists, water managers and policy-makers have moved increasingly towards the view that the global climate is changing significantly, and may be expected to change further through many decades in future, it has been recognized that there are likely to be changes in flood risk in many parts of the world (Black *et al.,* 2001). In many research projects for policy planning strategic alternatives

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for long-term policy making are being developed and evaluated. Their assessment nowadays often involves assessing their performance in different future scenarios (de Bruijn *et al.,* 2008). The reports show half of world population will live in coastal area until 2030 (Small and Nichols, 2003) and the flood management is one of the biggest parts of integrated coastal zone management (ICZM). Finally, this Management actually takes place on two different levels of actions:

- Resilience strategies: aim at minimizing flood impacts and enhancing the recovery from those impacts (de Bruijn, 2003)
- Resistance strategies: Resistance strategies aim at flood prevention for flood management. (de Bruijn, 2003)

Consequently, this study tries to develop the methods to find strategic options in flood management and weight the scores of the different alternatives to find which strategic alternative scores is the best across all scenarios.

MATERIALS & METHODS

The documents show the developments in decision support system begun with building mode-driven DSS in the late 1960s, theory development in 1970s and the implementation at financial planning systems spread sheet DSS and group DSS in the early and mid 1980s. Executive information system and business intelligence evolved in the late 1980s, mid early 1990s. Finally, the chronicle ends with knowledge-driven DSS and the implementation of web- based DSS in the mid 1990s. Also, (Little, 1970) they identified criteria for designing models and systems to support management decision-making. His four criteria included: robustness, ease of control, simplicity, and completeness of relevant detail. All four criteria remain relevant in evaluating modern Decision Support Systems. Scott Morton, 1971, studied how computers and analytical models could help managers to make perfect in key business planning decision. He conducted an experiment in which managers actually used a Management Decision System (MDS). The study of decision support system is an applied rule that uses knowledge and especially theory from other disciplines. For this reason, many DSS research questions have been examined because they were of concern to people who were building and using specific DSS. Thus much of the DSS knowledge base provides generalizations and directions for building more effective DSS (Baskerville & Myers, 2002; Keen, 1980).

Knowledge-driven DSS can suggest or recommend actions to managers. These DSS are person-computer systems with specialized problem-solving expertise. The “expertise” consists of the knowledge about a particular domain, understanding of problems within that domain, and “skill” at solving some of these problems (Power, 2002). These systems have called suggestion DSS (Alter, 1980) and knowledge-based DSS (Klein and Methlie, 1995). Goul et al. (1992) examined Artificial Intelligence (AI) contributions to DSS. In 1965, a Stanford University research team led by Edward Feigenbaum created the DENDRAL expert system. DENDRAL led to the development of other rule-based reasoning programs including MYCIN, which helped physicians diagnose blood diseases based on sets of clinical symptoms. The MYCIN project resulted in development of the first expert-system shell (Buchanan & Shortliffe, 1984).

The idea of model-driven spatial decision support system (SDSS) evolved in the late 1980’s (Armstrong *et al.,*1986) and by 1995 the SDSS concept had become firmly established in the literature (Crossland *et al.,* 1995). Data-driven spatial DSS are also common.To provide a full DSS in ICZM, there are 3 main steps call 3S. (Fabri, 1998) the SSS methodology represents for sustainable development in coastal area. This study uses strategic management and DSS together, at the end; two methods are compared after ranking and choosing strategic options for flood management in coastal zone. In 3S methodology 3 phases are shown as below:

- Screening define data collection and data base
- Scoping defines the stakeholders and problems and objectives.
- Scanning is development and evaluation of strategic alternatives. (The main part of methods)

Development of this methodology requires quantitative methods in all sections of Multi Criteria Analysis (MCA). In the other hand, strategic development is the biggest problem for engineering systems; this study tries to find quantitative method for definition of the best strategic alternative in DSS models.

Many engineering efforts have developed mathematical methods, fuzzy logic, game theory and etc. in DSS model, but there are not clear methods in choose of strategies. Consequently, all above mentioned studies go in wrong way with many uncertainties.

- **SWOT Analysis to define Strategic Alternatives**

The SWOT is one of the famous tools to evaluate of strengths, weaknesses, opportunities and threats in each system. This technique is crated by Stanford University in the 1960s and 1970s for business companies. But there are many similarities between coastal systems and companies. In both of them, the strategies are generated by asking and answering of following questions:

How can use strengths?
How can stop weaknesses?
How can exploit opportunities?
How can defend against threats?

For flood management SWOT analysis is applied to define strategic options in coastal zone management. In this study the aim of SWOT analysis is to identify internal and external factors to achieve above mentioned targets. The strengths and weaknesses are presented by internal factors. The opportunities and threats are shown as external factors to the coastal area. To summarize the SWOT methodology, in next step, the below table 1 should be filled. This table has 4 sections which show; related strategic options. Section 1 belongs to strategies to use maximum opportunities with strength positive potential of coastal areas (SO). Section 2, divides some strategies to apply strengths against the threats (ST). Section 3, is for strategies that use opportunities to cover weaknesses (WO). Section 4, minimizes weaknesses and threats (WT). Table (1) shows S, W, O and T in coastal area regarding flood management.It is filled by 4 strategic groups. There are 10 strategies; listed below are gain from SWOT analysis for complete analysis and achieving better results:

S_1: Apply systematic methodology in shoreline management plan
S_2: 50 years program to protect Coastal zone against erosion
S_3: Flood warning and evacuation measures in tropical storm
S_4: To build dike in lowland area against sea level rise
S_5: Focus on sustainable development to protect people, planet and property
S_6: Apply synoptic station to prediction of hydrodynamic factors
S_7: Wetland protection as natural resistance in floodplain
S_8: Education and training of coastal managers to follow ICZM regulations
S_9: Change in land use & Construction of flood resistant buildings
S_{10}: Do nothing strategy (it is evaluated to show the level of disaster in no action scenarios and have comparison between this option and others)

The above mentioned strategies are categorized in 5 main groups:
SP1: To build dike and use erosion program to protect Coastal zone
SP2: Change in land use & Construction of flood resistant buildings with training and education, focus on sustainable development
SP3: Apply systematic methodology in shoreline to protect wetlands as natural resistance
SP4: Apply systematic methodology in shoreline, Flood warning and evacuation measures with employ synoptic station to prediction of hydrodynamic factors and focus on sustainable development
SP5: Do nothing strategy

To gain the best alternatives for flood management in coastal area, the DSS model can be used. In the next steps, the best scenarios are defined and compared with two methods:
Method a: choose the best option with Multi Criteria Analysis (MCA), in accordance to environmental indexes.
Method b: Quantitative Strategic Planning Matrix (QSPM), in this method the best alternatives are chosen based on Strengths, weaknesses, opportunities and threats.
For both methods, analytical hierarchy process (AHP) is applied.

RESULTS & DISCUSSION

DSS and MCA, to select best scenarios

The basic steps of multi criteria decision analysis in this study are shown in Fig. 1. Each

Table1. SWOT analysis for flood management in south- east of Iran

External Factors / Internal Factors	Threats					Opportunities				
	Erosion and sedimentation	Sea Level Rise (Permanent)	Storm Surge	Tsunami	Un controlled Development in Coastal zone	Study on ICZM and EIA in coastal area	Increase coastal budget	Protection of wet land	Change in land use & flood resistant buildings	Flood warning and evacuation measures
Strengths										
Forest & Woodland	*		*	*	*	*			*	*
Sandy beach & Tourism	*	*			*	*	*		*	*
wetland	*	*			*			*		*
Natural protection system	*	*			*			*		*
Landscape					*	*		*	*	*
Weaknesses										
Poor database	*		*	*		*	*			*
Lack of hydrograph station			*	*			*			*
Lack of synoptic station			*	*			*			*
Lack of training		*					*	*	*	*

multi criteria, starts with problem definition and available data in spatial atmosphere is collected. The possible strategies are defined with SWOT analysis and criteria aims at evaluation of their performance are identified with scores of each strategy under criteria, and DSS matrix is constructed. Table (2) shows the range of each criteria and normalized values. The total score of each strategy are shown in Table (3).

Table 2. evaluation effects

Effect	Domain	Rang
low very	VL	0-2
low	L	2-4
Medium	M	4-6
High	H	6-8
very high	VH	8- 10

The measurable criterions are used by group of expert in KNT University in accordance with pair wise comparison.For calculation of the result and normalize the quantitative and qualitative criteria, numerical model based on MatLab, software are used. The strategy performance with regard to different criteria should be compared to numerical methods. All scores normalize 0 to 1, but for good adaptation with management methods the range 1 to 10 are used and the values are started at 1. The flood management scenarios which are gained from SWOT analysis are ranked with ICZM criteria and score base on analytical hierarchy process (AHP). The AHP method in DSS models shows that the SP4 is the best option for flood management in coastal area. (Table 3).

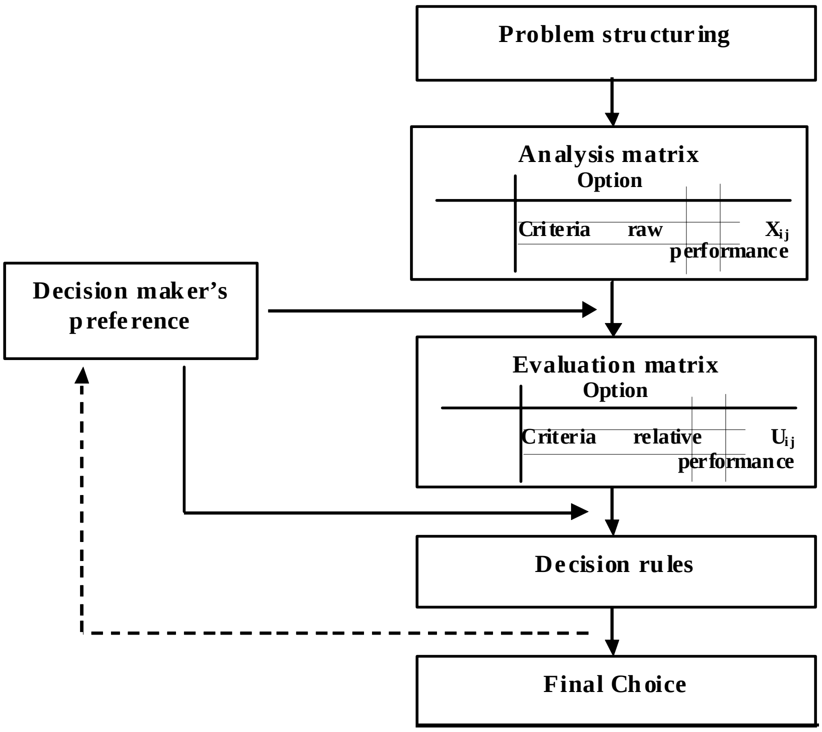

Fig. 1. The Basic Steps of the MCA (http://www.netsymod.eu)

Table 3. evaluation of effects in DSS method

scenario / Criteria	weight	SP1		SP2		SP3		SP4		SP5	
		V	S	V	S	V	S	V	S	V	S
Water resource protection	0.3	4.39	1.32	4.10	1.23	3.80	1.14	6.67	2.00	3.18	0.95
Tourism development	0.1	3.88	0.39	3.59	0.36	3.99	0.40	7.18	0.72	2.65	0.27
Health quality	0.15	4.08	0.61	3.08	0.46	4.28	0.64	5.64	0.85	2.12	0.32
Environmental protection	0.2	4.69	0.94	4.10	0.82	4.75	0.95	5.95	1.19	2.97	0.59
Cost efficiency	0.25	2.04	0.51	6.15	1.54	3.33	0.83	9.23	2.31	1.59	0.40
Total effect			3.76		4.41		3.96		7.06		2.53

- **Quantitative Strategic Planning Matrix (QSPM), to select best scenarios**

The integration of management factors in costal area is the most important target and DSS methods should be applied with quantitative parameters. This study shows all part of DSS with quantitative methods to achieve this target. Meanwhile the application of strategic management is assessed. In this section, the scenarios of flood management are score and sorted based on QSPM method. The difference between QSPM method and DSS model are the "criteria definition". In Section 2-3, the strategic alternatives in flood management are ranked in accordance with ICZM criteria are defined by fabbri, but in QSPM methods the options are sorted by Strengthens, Weaknesses, Opportunities and Threats. The numerical models are applied upon Analytical Hierarchy Presses. The result has been shown in Table 4 and the S_3, S_6, S_5 and S_1 are sorted as the highest Scores. Consequently, SP4, combination of 4 strategies, is the best one with this method.

To this end, a multi criteria analysis framework has been established within which two types of analysis fit coherently: using spatial decision support system model to rank strategic alternatives and QSPM method to define the SWOT out lines for best option. In both case SWOT analysis are applied to strategies definition and analytical

Table 4. QSPM method to select best strategic option flood management

QSPM		S_1		S_2		S_3		S_4		S_5		S_6		S_7		S_8		S_9		S_{10}	
Strengths	**weight**	V	S	V	S	V	S	V	S	V	S	V	S	V	S	V	S	V	S	V	S
Forest & Woodland	0.2	4	0.8	4	0.8	4	0.8	4	0.8	3	0.6	4	0.8	2	0.4	2	0.4	4	0.8	2	0.4
Sandy beach &Tourism	0.15	3	0.45	2	0.3	4	0.6	4	0.6	4	0.6	3	0.45	2	0.3	3	0.45	3	0.45	2	0.3
Wetland	0.1	1	0.1	3	0.3	4	0.4	3	0.3	4	0.4	4	0.4	3	0.3	3	0.3	3	0.3	2	0.2
Natural protection system	0.1	1	0.1	1	0.1	2	0.2	3	0.3	2	0.2	4	0.4	1	0.1	1	0.1	1	0.1	1	0.1
Landscape	0.15	2	0.3	4	0.6	3	0.45	2	0.3	1	0.15	2	0.3	1	0.15	1	0.15	4	0.6	1	0.15
Weaknesses																					
Poor database	0.07	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07	2	0.14	2	0.14	2	0.14	1	0.07	1	0.07
Lack of hydrograph station	0.07	1	0.07	1	0.07	2	0.14	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07
Lack of synoptic station	0.07	1	0.07	2	0.14	2	0.14	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07	1	0.07
Lack of training	0.09	2	0.18	2	0.18	1	0.09	1	0.09	1	0.09	2	0.18	1	0.09	2	0.18	2	0.18	1	0.09
Opportunities																					
Study on ICZM and EIA in	0.07	3	0.21	1	0.07	4	0.28	2.5	0.175	4	0.28	4	0.28	3	0.21	3	0.21	3	0.21	2	0.14
Change in land use& flood	0.12	4	0.48	1	0.12	4	0.48	2.7	0.324	4	0.48	3	0.36	3	0.36	3	0.36	3	0.36	2	0.24
Protection of wet land	0.05	2	0.1	1	0.05	4	0.2	3	0.15	4	0.2	2	0.1	3	0.15	3	0.15	1	0.05	1	0.05
Increase coastal budget	0.08	3	0.24	2	0.16	3	0.24	2	0.16	4	0.32	3	0.24	3	0.24	2	0.16	3	0.24	2	0.16
Flood warning and evacuation	0.2	4	0.8	1	0.2	2	0.4	4	0.8	3	0.6	4	0.8	2	0.4	1	0.2	1	0.2	1	0.2
Threats																					
Erosion and sedimentation	0.06	1	0.06	1	0.06	2	0.12	1.5	0.09	1	0.06	1	0.06	1	0.06	1	0.06	1	0.06	1	0.06
Sea Level Rise (Permanent)	0.12	2	0.24	1	0.12	1	0.12	1.5	0.18	1	0.12	1	0.12	2	0.24	2	0.24	1	0.12	1	0.12
Storm Surge	0.14	2	0.28	1	0.14	2	0.28	1	0.14	2	0.28	2	0.28	2	0.28	2	0.28	2	0.28	1	0.14
Tsunami	0.06	1	0.06	1	0.06	2	0.12	1	0.06	1	0.06	1	0.06	2	0.12	2	0.12	1	0.06	1	0.06
Un controlled Development in	0.1	1	0.1	1	0.1	2	0.2	1	0.1	1	0.1	1	0.1	1	0.1	2	0.2	1	0.1	2	0.2
Final Scores			4.71		3.64		5.33		3.14		4.75		5.21		3.78		3.84		4.32		2.82
Ranking			4		8		1		9		3		2		7		6		5		10

Table 5. Comparison of two methods

DSS Method	SP1	SP2	SP3	SP4	SP5
	3.76	4.41	3.96	7.06	2.53

QSPM Method	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
	4.71	3.64	5.33	3.14	4.75	5.21	3.78	3.84	4.32	2.82

SP4 = S3 + S6 + S5 + S1

hierarchy process (AHP) are used to scores. The comparison of these two methods shows that the best alternative is the same Table (5).

It means SP4 (apply systematic methodology in shoreline, Flood warning and evacuation measures with employ synoptic station to prediction of hydrodynamic factors and focus on sustainable development) is the best strategic alternative in flood management systems in south-east of Iran.Meanwhile the results show that SWOT analysis help to decision makers to define correct strategy in flood management and all parts of the method which is offered in this study adjust with quantitative methods.

CONCLUSION

The management of coastal flood hazard reflects the cumulative effects and criteria more than the human mind can handle effectively. It is recommended that systematic methods to choose best strategic alternative in flood management have been used and to reach this target numerical models in multi criteria decision making should be developed. It means applying quantitative methods with a combination of DSS and SWOT analysis in flood management helps coastal managers to decrease uncertainties and human errors.

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