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Managing coastal activity conflicts using spatial multi-criteria assessment approach: A case study of Ras Al-Khaimah, UAE

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Abstract

Most coastal areas all around the world have multiple uses, which involve a large number of human activities. These designated areas of multiple-use attract a variety of competing uses, which sometimes overlap causing spatial conflicts and adverse effects on the coastal marine environment. Introducing a multi-criteria assessment model for identifying and managing conflicts in multi-use coastal areas of Ras Al Khaimah. Multi-criteria assessment modelling (MCAM), which is a part of the marine spatial planning framework process, involves steps supported by digital mapping systems as a geographical information system (GIS) and ranking module. Digital mapping system tools as GIS was used in identifying overlapping coastal uses as well as, mapping conflict hotspots and ranking module, which will be the result of engaging relevant stakeholders and user groups to interpret. Assessment model data into a digital format, which highlights the conflicts grading along the coastal line. Through this study, we can easily identify the major and minor conflicts zones, which enables a foundation for future planning of Ras Al Khaimah Coast. The successful implementation of MSP in resolving conflicts depends on the extent of the stakeholder's involvement, data availability and existing knowledge base.

Keywords: Multi-Criteria Assessment Model, GIS, Stakeholder's Engagement, Coastal Management, Ras Al Khaimah

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1. Introduction

Many countries are attempting to manage conflicts between coastal resource users and halt environmental damage. Among the many approaches, integrated coastal zone management (ICZM) (Cicin-Sain and Knecht, 1998) and ecosystem-based management (EBM) (McLeod et al., 2005) have been used to implicitly address the management of conflicts among different coastal resource users. These approaches emphasize the integration and balancing of multiple objectives in the ecosystem planning process (Christie et al., 2005; UNEP, 2011). GIS is widely utilized inside these ways to enhance spatial administration (Vallega, 1999, 2005).

Whilst these approaches, new trends of conflicts are now emerging as demand for coastal resources increase (such as tourism, conservation, ports and fisheries). These raising demands led to initiate more strategies that are efficient that emphasis of multiple decision making in balancing economy, environment protection and social demands. Multi-criteria assessment modelling (MCAM) or analysis has been promoted as one of the advanced urban planning evaluating techniques. This technique is widely used as a method that could overcome uncertainty, and provide decision-makers with more reliable results, indicated the applicability to a range of urban planning issues (Funtowicz and Ravetz, 1994).

Whilst the coastal and estuarine areas of high ecological and economic value are widely recognized, they have become highly susceptible and influenced by many human activities, especially with human populations continuously increasing and aggregating around coastal areas worldwide, space for human settlement and activities is often gained through land reclamation (Vasconcelos et al., 2017).

Different types of multi-criteria models are articulated as per the nature of the context that we look into. For instance, in environmental planning and management multi-criteria decision, making (MCDM) is adaptable, and Cost–benefit analysis (CBA) could be classified as a multi-criteria method for environmental problems. Therefore, the choice of method should be well justified in real applications, although this is rarely done. Considering multi-criteria methods, MSP has recently been promoted as one of the strategies that can help address complex conflicts in coastal and marine areas.

MCAM is used as a framework to identify high to low significant conflict zones existing and how alternative solutions might be evaluated. In this paper, we report findings of coastal conflict resolution process that utilized the MSP process. Motivated by multi-use conflict (focused on user-environment conflict) in Ras al Khaimah's coastal area, we have attempted to apply MSP to identify the existing conflicts and illustrate the level of significance with recommendations for problems. The utility of MSP in determining and addressing coastal conflicts and implementation challenges are addressed.

This approach is considered as a methodology that has been used in the context of environmental planning and project appraisal to address conflicting objectives between stakeholders over the use of scarce natural resources (Malczewski, 1999). Information about the physical environment, the ecosystem and social structures can be integrated into a multi-criteria framework. With the help of this information, critical incompatibilities and overlapping interests can be discovered. When MCAM is combined with GIS, it provides the decision-makers with a more rational, objective and unbiased approach to spatial decision making (Heywood et al. 2002).

The combination of MCAM and GIS in marine spatial planning has been used in several studies (e.g. Villa et al., 2002; Brown et al., 2001; Brody et al., 2004, 2006). Combined multi-criteria – optimization approaches are being used progressively in environmental planning to facilitate spatial planning, particularly as a means of reducing conflict.

1.1. Study area

This study was conducted in the RAK Khor coastal area, which is considered as the heart of Ras al Khaimah north emirate. This area is under the jurisdiction of local and federal entities as it consists of a huge number of human activities, including conservation zones and ports. This study focused on the intensive activity coastal zone measuring up to 5 km2 (Figure 1).

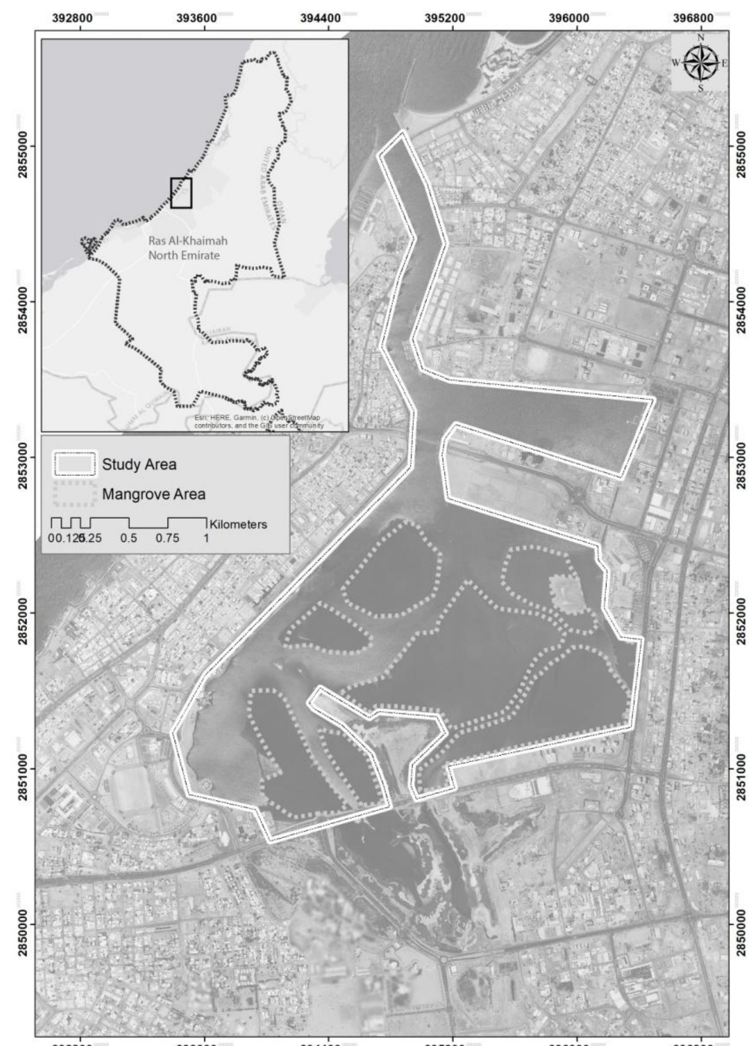

Figure 1. Map of Rak Khor, Ras Al-Khaimah north emirate, UAE, Showing the study area boundary and mangrove location

The RAK Khor coastal area is a complex mosaic of human activities and habitats. The main uses typically fall under recreational, tourism, commercial fishing, port and conservation. The habitat includes mangrove swamps, seagrass beds, salt marshes, coastal, dunes and oyster beds) (Binsal, 2007) and creek opening to extensive sandy beaches. These habitats perform various environmental and biodiversity functions. Also, services including stock of biodiversity and tourism. Consequently, this area attracted many users for its characteristic and scenic nature, which lead to an increase in conflicts. And these conflicts impeded development and coastal conservation area.

For instance, mangrove marches were sacrificed for new developments, including a motorway, a golf club and two shopping malls. These are usually exacerbated by different government entities, which are responsible for licensing various activities in the area without appropriate consultation/analysis. In the absence of guidelines and fragmented sectoral regulations have not been well understood or integrated. These conflicts resulted in ecological damage, which has hindered the effectiveness of management of critical ecological areas. Meanwhile, emerging Conflicts were addressed in an ad hoc manner because there were no legal instruments for coastal conflicts and mechanisms to allow stakeholders to participate in the planning/decision-making process. This study, therefore, undertook to address existing conflicts using a multi-criteria assessment approach of the marine spatial planning process. Port industry and recreational activity such as enclosed hotels are growing here and may have an impact on the environment, so we need to maintain this mangrove area with affiliated habitats to provide fresh air for the people and to maintain the ecological balance. The RAK Khor and the port is an important location to study coastal zone environmental conflicts for the following reasons: 1) The Khor area has critical habitats – Mangroves – that are endangered and require preservation 2) These ecosystems are a significant source of coastal livelihood for fishing and tourism activities, 3) Various agencies are responsible for managing stakeholder activities in the Khor and port, and the area is adjacent to the populous city, which makes it a place for conflicts with the coast environment.

2. Methodology

2.1. Multi-criteria assessment model followed steps

A schematic flowchart illustration of logical steps followed in this study is shown in Figure 2. The conflict analysis applied is composed of three phases. First, conflicting stakeholder values and the level of importance for the uses are determined (Ehler and Douvere, 2009; Gilliland and Laffoley, 2008). The information describing the marine habitats and human activities was incorporated in the step-by-step MSP process to guide decisions on conflict and allocation of coastal spaces (Ehler and Douvere, 2009; Gilliland and Laffoley, 2008).

These values represented hierarchically in the form of goals, objectives or criteria, and attributes using MCAM. Consistently, the attribute allocated using geographical information systems (GIS) for evaluating the conflict areas. Finally, optimization techniques (Malczewski et al., 1997) for minimizing the current identified conflicts were used to predict scenarios for any future conflicts and to proposed zonal plans. The three main steps in the MCAM were: 1) MCAM Preparations; 2) identifying and evaluating the current situation; 3) Optimization marine zoning plan. These steps allowed for the inclusion of stakeholders at different stages of the process (Guenette and Alder, 2007; Gopnik et al., 2012). After constructing the importance hierarchy, weights of relative importance are assigned to individual objectives and attributes in each level of the hierarchy. The weight indicates the degree of importance attached to the objectives and attributes relative to others under consideration. The pairwise comparison technique is applied in assigning the weights (Saaty, 1980). The method involves pairwise comparison to create a ratio matrix and these values will be identified by stakeholders according to each specialized category (Government agency experts -local institutions and users – Academics).

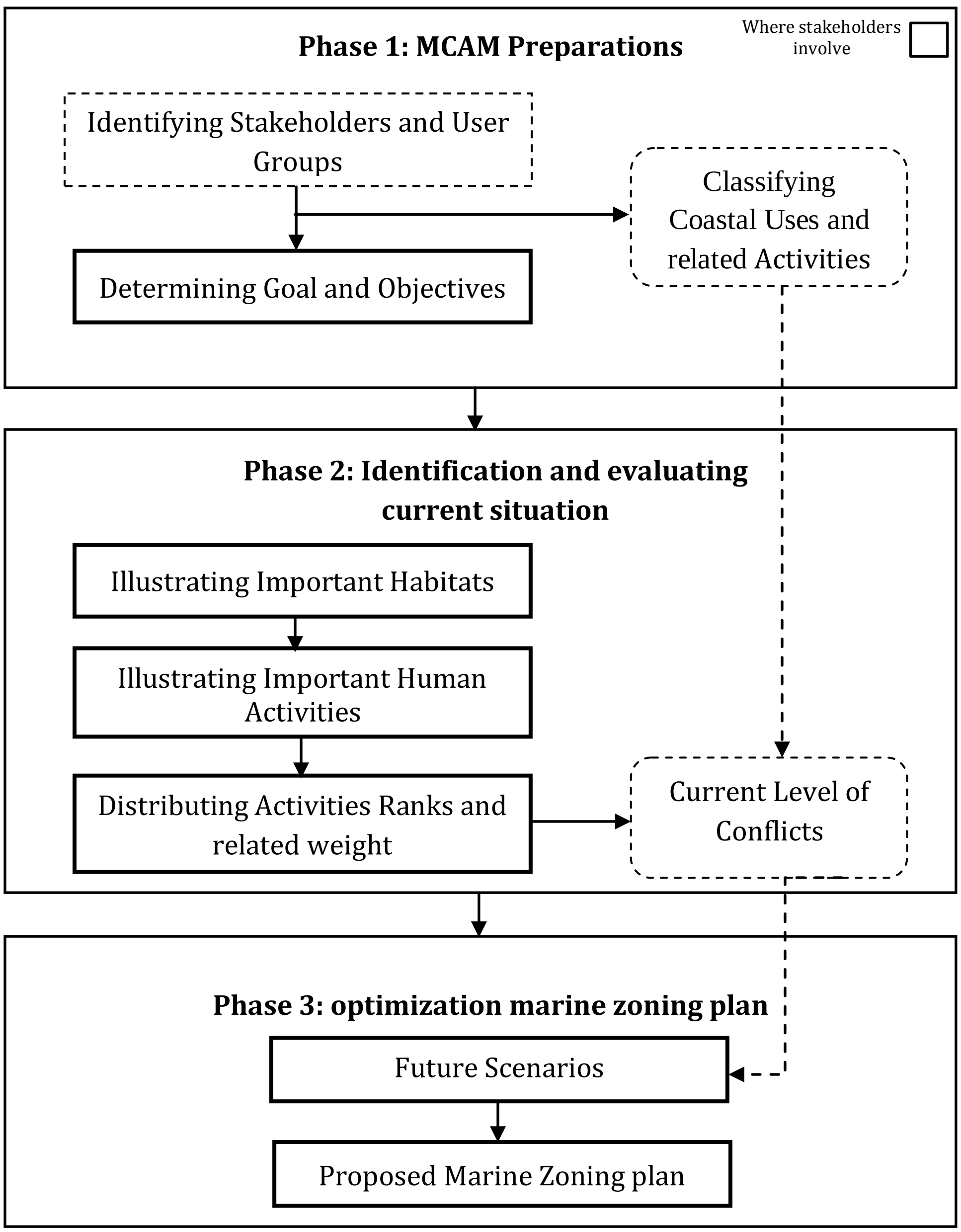

Figure 2. Steps followed in the marine spatial planning process (Adapted from Ehler and Douvere, 2009)

2.2. Multi-criteria assessment modelling (MCAM) preparations

The MCAM Preparations process involved identifying stakeholders to participate in the conflict resolution process, and defining desired conflict resolution outcomes (goals and objectives). Stakeholder engagement is an inherent aspect of MCAM (Gilliland and Laffoley, 2008; Guenette and Alder, 2007; Gopnik et al., 2012) and it had been critical to different stages of the conflict resolution process. Three considerations were made before involving stakeholders to make sure expected results a minimum of costs: 1) who should be involved; 2) how should stakeholders be involved; 3) when should stakeholders be involved (Maguire et al., 2012) Coastal resource users and management agencies whose activities contributed to the conflicts were identified and involved within the process at different stages within the MCAM process (Figure 2). The first list of stakeholders was derived from the Environment Protection & Development Authority management plan; this included stakeholders who are direct users of the marine resources, e.g. fishers, tour operators and the regulatory agencies. The stakeholders were then classified into three levels (Bunce et al., 2000). The first level of stakeholders was competing user groups whose activities contributed directly to the use conflicts, and this level of stakeholders was represented by ten user groups that were classified into five uses: habitat conservation, sea access and anchorage; water recreation; beach activities; and artisanal fishers. The second level stakeholders were experts from four government agencies responsible for regulating the coastal uses: Ras al Khaimah Tourism development authority (RAK-TDA); Ras al Khaimah Environment Protection Development Authority (RAK-EPDA); Ras al Khaimah Ports and Ras al Khaimah Municipality Department. The second level of stakeholders list was developed based on the selected user groups and identifying who licenses their activities. The third level of stakeholders were the academics who are working in Ras al Khaimah universities who have done relevant research on the coastal region and have been resulting from different theoretical backgrounds.

Their presence was an essential step as a comprehensive evaluation of all coastal activities that would be collected from different points of view, which could assist in the optimization of marine plans. After the stakeholders were selected, a conflict initial meeting was held with stakeholders to agree on the conflict resolution objectives. Clear objectives provide the context for the MCAM steps, which is also considered as a part of the marine spatial planning process (Gilliland and Laffoley, 2008). The objectives of this conflict resolution were formulated as 1) minimize existing conflicts in the Ras Al-Khaimah coastal area to the lowest level; 2) to allocate spaces optimally to competing for human activities.

2.3. Identification and evaluating the current situation

The second step in the MCAM process was to analyze current spatial conflicts. We used a GIS-based multi-criteria decision analysis (GIS-MCAM) in a structured decision framework with a combination of the geographical data set (such as coastal habitats and human activities) and their relative weight of importance to conflicts as elicited by stakeholders (Malczewski, 2006). This approach is widely used in environmental decision-making for formalizing and addressing competing decisions objectives (Malczewski, 1999). In coastal areas, it has been used for addressing conflicts and conservation planning (Villa et al., 2002; Brown et al., 2001; Brody et al., 2004). GIS-MCAM supports critical analysis and visualization of spatial incompatibilities and overlapping interests (Heywood et al., 2002). The first-step in GIS-MCAM includes gathering geographical information of all human activities and coastal-marine habitats, which are illustrated into five different categories of coastal uses, as shown in (Table 1).

Spatial data of coastal habitats were obtained from a secondary source, RAK-EPDA GIS database, while data on human activities were collected from field surveys with the involvement of competing user groups. Individual user groups in field exercise participated in the collection of data, which stated the geographical position of their respective use. The participants in field data collection were, therefore done through the respective groups based on their specialization. The officials of all groups were given the list of characteristics for stakeholders' representatives and asked to select their representatives. Table 1 shows the coastal uses and the respective user groups. All information was arranged and managed in a geodatabase format. For spatial analysis purposes, all critical habitat and marine human activity data were transformed into raster map layers, this operation calls. A Boolean map contains pixel and each pixel value indicating whether there is human activity. Hence, the values were 0 when the habitat or human activity existed, and pixel values were 0 otherwise. In a habitat or human activity map layer, and based on these values, the contribution rate of coastal activities in the conflict was calculated according to the importance weight of each activity.

Table 1. Criteria (habitats and human activities) used in the MCAM and description of stakeholders associated with respective criteria

Coastal uses	Criteria for MCAM	Spatial Data	User Group
1. Habitat Conservation	Mangrove	Locations of mangrove coverage area	The EPDA manager and staff
	Seagrass beds areas	Locations of seagrass beds. Seagrass beds are	
		Submerged vegetation associated with coral reefs.	
	Coral reef	Location of corals and the reef, which occurs as a fringing reef and patch corals.	
	Intertidal mud/sand flats	Locations of habitats that are periodically inundated and exposed to the tidal ebb. The habitats are foraging grounds for many shore and migratory birds.	
	Sandy beach	Areas characterized by bare sand. They are often slightly vegetated	
2. Sea access And anchorage	Sailing	Locations used by water sport operators for sailing, windsurfing	Beach hotels water sport owners with surfs and local tour operators using traditional wooden boats with sails for recreational activities

	Jet Skiing	Jet Ski designated areas	Beach hotel water sports operating jets skis for hire
	Anchoring mooring of vessels	Areas used for vessel anchoring	Local boat operators who use inshore areas along the beach to anchor their vessels
	Ports	Location of port areas	Trading and marine transport services providers
3. Water Recreation	Kayaking	Location of kayaking areas	Kayaking service providers
	Snorkelling	Locations used tourists for snorkelling	Local boat operators
	Inshore recreation	Locations of Intertidal areas used by public	Tube renters, people renting out floatation devices for swimmers and who dominate the inshore areas Pedal boat renters who rent out pedal boats along the beach
4. Beach Activities	Curio stalls	Location of curio traders on the beach	Curio dealers who sell their wares on the beach
	Safari selling	Location of safari sellers on the beach	Safari sellers who are tour operators operating along the beach
	Boat operations	Location of boat operators on the beach	Members of the Boat Operators Association
	Other activities	Location of various activities on the beach	Other beach operators including food vendors
5. Artisanal Fishing	Basket/trap fishing	Locations where fishers use basket traps	Fishers using basket traps and non-motorized vessels
	Gill netting and line fishing	Areas where fishers use gill nets and lines	Using gill nets with motorized on non motorized vessels
	Gleaning	Locations mainly on the reef where fishers collect octopus and other invertebrates	Fishers who glean for octopus on foot
	Beach seining	Locations of used by fishers using beach seines	Fishers using drag nets in intertidal areas
	Landing and mooring sites	Areas used by fishermen for vessel anchorage and landing catches	Fish vendors and all groups of fishers

In such an organized framework it is possible to combine a set of geographical data (coastal habitats and human activities) and their relative weight of importance for conflicts as selected by stakeholders

(Malczewski, 2006). This approach is well recognized and has been used widely used in environmental decision-making for formalizing and addressing competing decision objectives (Malczewski, 1999). It has been used for identifying conflicts in coastal areas, (Villa et al., 2002; Brown et al., 2001; Brody et al., 2004). GIS-MCAM supports the analysis and visualization of spatial incompatibilities and where interests overlap with each other (Heywood et al., 2002).

The first-step in the GIS-MCAM was to gather geographical information on competing for coastal human activities and marine habitats, which categorized into five coastal uses (Table 1). Spatial data on coastal habitats were obtained from the stakeholder second level source Environment Protection Development Authority (EPDA), while data on human activities were collected from field itself with the help of each activity user group. The participants in field data collection were, therefore done through the respective groups. The officials of all groups were given the list of characteristics for stakeholder representatives and asked to select their representatives.

Table-1 describes mapped use areas and related user groups. All spatial data was organized in (ESRI) geodatabase format then, all habitat and human activity data were transformed into raster map layers for spatial analysis purposes.

Coastal uses, their corresponding habitats and human activities in (Table 1) contribute to conflicts with different levels, so it was vital to assign them weights of importance. These weights of importance were given based on the evaluation of ranks that were developed by experts from governmental agencies, activity user groups and academics with relative compatibility of one criterion over another (Malczewski, 1999).

It was done hierarchically with the participation of stakeholder's three levels in a discussion group. The raster map layer consists of pixels; each pixel indicates whether there are human activity and habitat or not as if the pixel = 1 where habitat or human activity is presented and pixel = 0 where not as well as, each pixel has a value which represents each activity area. Accordingly, the relative weight of the importance of each activity had to be calculated using a pairwise comparison of the relative compatibility (Table 3) of one criterion over another (Table 3) (Malczewski, 1999).

Table 2. Compatibility scale pairwise comparison

Compatibility rank	Description
5	Compatible
3	Probably Compatible
1	Incompatible

Note: these scores are based on the different criteria assessments of stakeholders through workshops

The comparison was made at three levels of stakeholders. The first level of comparison was made between coastal uses, the second level of comparison was made between habitats, and human activity, which is under coastal, uses (Table 1). The weights of coastal uses, which were done by the second, level of stakeholder Represented by government agencies experts (TDA – EPDA – Ports – Municipality). Considering these agencies have related interest in and knowledge of coastal conservation, tourism and fisheries issues in the RAK Khor.

After assigning weights for each activity under coastal use, we used GIS raster calculations for combining the habitats and human activity pixel value (P_x) with their related weight (W_x) to define the conflict level for individual habitats and human activities (Malczewski, 1999). The higher level of conflict indicated a significant contribution to the conflicts. To get the new level of conflicts (CL_{a1}), we used the map layer with the equation.

$$CL_{a1} = \sum_x P_x W_x \quad \text{(Eq. 1)}$$

After getting conflict value for each activity, we divided each value statistically by the maximum conflict value to get the standardized overall score for the location CL'_{a1} and CL_a^{max} was the highest score

$$CL`_{a1} = \frac{CL}{CL_a^{max}}$$

The values were categorized from 0 to 1 and were ranked qualitatively (Table 4); the higher the value, the higher the level of conflict (Malczewski, 2006).

Table 3. Current coastal uses and related habitats with user activities assigned weights

Compatible / Probably Compatible / Incompatible		Mangrove	Seagrass beds areas	Coral reef	Intertidal mud/sand flats	Sandy beach	Sailing	Jet Skiing	Anchoring	Ports	Kayaking	Snorkelling	Inshore recreation	Curio stalls	Safari selling	Boat operations	Other activities	Basket/trap fishing	Gill netting	Gleaning	Beach seining	mooring sites	Total	Current Weights
1. HC	Mangrove	5	5	5	5	5	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	43	0.0471
	Seagrass beds areas	5	5	5	5	5	3	3	3	3	3	3	3	3	3	3	3	3	1	1	3	3	69	0.0757
	Coral reef	5	5	5	5	5	1	1	1	3	3	3	1	1	3	3	3	1	1	1	1	1	53	0.0581
	Intertidal mud	5	5	5	5	5	1	1	1	3	3	3	1	1	3	3	3	1	1	1	1	1	53	0.0581
	Sandy beach	5	5	5	5	5		3	3	3	3	3	1	1	3	3	3	1	1	1	1	1	56	0.0614
2. SA	Sailing	1	1	1	1	1	5	1	1	1	3	3	3	3	3	3	3	1	1	1	1	1	34	0.0373
	Jet Skiing	3	3	3	3	3	3	5	3	1	1	1	1	1	1	1	3	1	1	1	1	1	41	0.0450
	Anchoring	3	3	3	3	3	3	3	5	5	3	3	3	3	3	3	3	1	1	1	1	1	57	0.0625
	Ports	1	1	1	1	1	3	3	5	5		1	1	1	1	1	3	1	1	1	1	1	34	0.0373
3. WR	Kayaking	1	1	1	1	1	3	3	1	1	5		1	1	1	1	3	1	1	1	1	1	30	0.0329
	Snorkeling	1	1	3	1	1	3	3	1	1	3	5	1	1	1	1	3	3	3	3	3	3	45	0.0493

	Inshore recreation	1	1	1	1	1	5	5	3	3	3	3	5	5	1	1	3	1	1	1	1	1	47	0.0515
4. BA	Curio stalls	1	1	1	1	1	3	1	1	3			3	5	5	1	3	1	1	1	1	1	35	0.0384
	Safari selling	1	1	1	1	1	3	1	1	1	1	1	1	5	5	1	3	1	1	1	1	1	33	0.0362
	Boat operations	1	1	1	1	1	3	1	1	1	1	1	1	1	1	5	3	1	3	3	3	3	37	0.0406
	Other activities	1	1	1	3	3	3	3	3	3	3	3	1	1	1		5	1	3	3	3	3	48	0.0526
5. AF	Basket/trap fishing	1	1	1	1	1	1	1	1	3	1	1	1	1	1	3	3	5	3	3	3	3	39	0.0428
	Gill netting and line fishing	1	1	1	1	1	1	1	1	3	1	1	1	1	1	3	3	3	5	3	3	3	39	0.0428
	Gleaning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	5	3	3	37	0.0406
	Beach seining	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	5	3	35	0.0384
	Landing and mooring sites	1	1	1	1	3	1	3	5	5	1	1	1	1	1	1	3	3	3	3	3	5	47	0.0515
Total																							912	1

Note: HC: Habitat Conservation - SA: Sea Access & Anchoring - WR: Water Recreation - BA: Beach Activity - AF: Artisanal Fishing

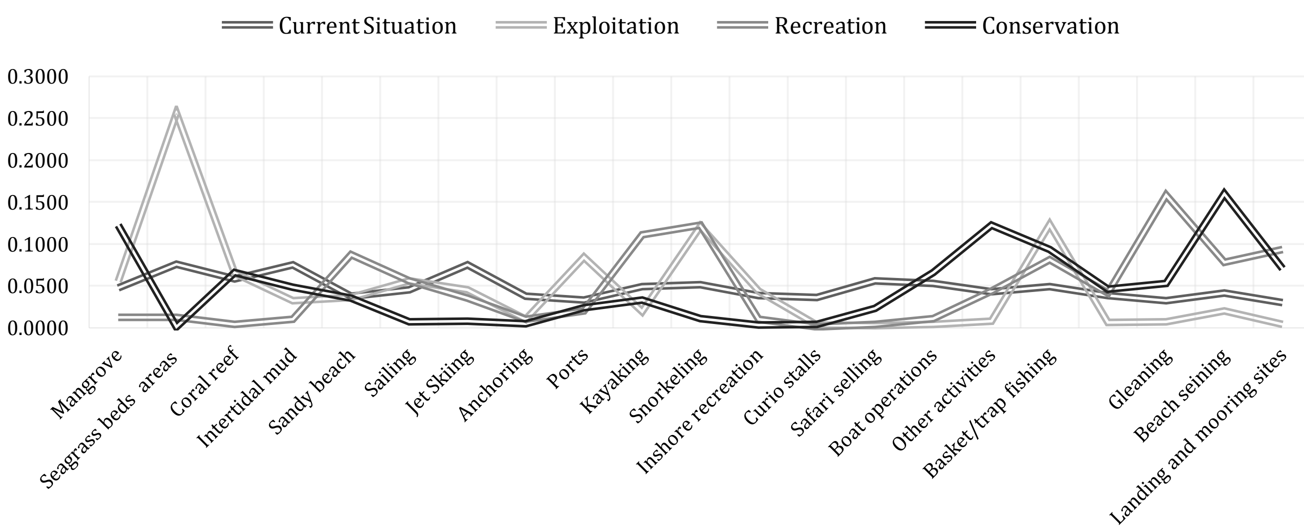

Figure 3. Future scenarios for coastal uses and related habitats with user activities assigned weights

2.4. Future scenario

This step aimed to make a projection on how future management actions will contribute to spatial conflicts. We put three scenarios, which will cause increased use of the RAK- Khor and port area 1) fisheries 2) recreation 3) conservation 4) (Figure 3).

Under the current management scenario (Figure 4a), low levels of conflict occur in both the port and mangrove areas. Low levels of conflict occur in areas of seagrass, which are also snorkelling, sailing, diving and trap fishing areas. High levels of conflict are caused by beach seining (a destructive fishing method) in seagrass beds and the intertidal mudflat areas. The mangrove area is characterized by “lowest” and “low” conflict levels because it is a no-fishing area. Changing management priorities would lead to an increase in spatial and location of different levels of conflict (Figures 4b, 4c and 4d). A summary of the areas covered by “highest” to “lowest” areas of conflict is shown in Table 4.

Table 4. Different levels of conflict

Conflict Score CL'_{a1}	Conflict category
0 – 0.3	Lowest
0.31 – 0.5	Low
0.51- 0.7	Moderate
0.71 – 0.9	High
0.91 – 1.2	Highest

Note: This value has been deduced from the GIS raster calculator layer

Increased use of the marine area for fisheries would potentially increase the spatial extent of current low and moderate levels of conflict (Figure 4b). Overall increased use of the Khor area for fisheries would potentially intensify present levels of conflict more than in other management scenarios. In comparison to current status, intensifying recreational activities in the marine area would increase the spatial coverage of low, moderate and high levels of conflict (Figure 4c). Low levels of conflict would increase 20% more than the current situation.

Locations of low conflict in the marine area would coincide with areas used for trap fishing and gill netting in the seagrass beds. These activities also compete with sailing and jet skiing. High conflict levels would occur in the same locations as at present. However, the highest levels of conflict would primarily be due to the existence of seining, which is incompatible with both sailing and inshore recreation.

Increased protection of habitats would potentially reduce low and high levels of conflicts, respectively (Figure 4d). These conflicts would occur in areas associated with seining, seagrass and fishing. The highest level of conflict would occur in particular locations where activities pose a threat to the habitats. Under both the recreational and habitat protection scenarios, the current locations of the low and moderate conflicts would remain unchanged.

Figure 4 shows that even under the current management scenario conflicts still exist in the Khor area. We used optimization marine zoning plan to allocate activities in a way that reduces the current and potential future conflicts, and there is another method to manage marine conflicts as integer goal program, this method was applied in similar cases to identify the activity, which will minimize the conflict levels in the current management scenario

The same calculation was followed to project the weights of compatibility for the three potential future scenarios 1) Fisheries / Exploitation 2) Recreational 3) Conservation. Using the GIS operations, activities’ weights were combined with the activity pixel value to obtain the expected conflict ratios that the activities contributed as presented in (Table 5)

Table 5. Future scenarios for coastal uses and related habitats with user activities assigned weights

Future scenarios for coastal uses and related human activities weights					
CU	Activities	**Current Situation**	**Exploitation**	**Recreation**	**Conservation**
HC	Mangrove	0.0471	0.0550	0.0120	0.1220
	Seagrass beds areas	0.0757	0.2558	0.0120	0.0010
	Coral reef	0.0581	0.0650	0.0040	0.0660
	Intertidal mud	0.0750	0.0320	0.0100	0.0480
	Sandy beach	0.0373	0.0360	0.0870	0.0350
SA	Sailing	0.0450	0.0560	0.0560	0.0070
	Jet Skiing	0.0750	0.0450	0.0350	0.0080
	Anchoring	0.0373	0.0100	0.0100	0.0050
	Ports	0.0329	0.0840	0.0200	0.0240
WR	Kayaking	0.0493	0.0190	0.1110	0.0330
	Snorkeling	0.0515	0.1211	0.1220	0.0110
	Inshore recreation	0.0384	0.0440	0.0100	0.0030
BA	Curio stalls	0.0362	0.0030	0.0010	0.0040
	Safari selling	0.0560	0.0020	0.0040	0.0230
	Boat operations	0.0526	0.0040	0.0110	0.0660
	Other activities	0.0428	0.0080	0.0440	0.1220
AF	Basket/trap fishing	0.0488	0.1230	0.0810	0.0930
	Gill netting and line fishing	0.0380	0.0060	0.0410	0.0460
	Gleaning	0.0320	0.0070	0.1580	0.0530
	Beach seining	0.0410	0.0200	0.0780	0.1600
	Landing and mooring sites	0.0300	0.0040	0.0930	0.0700
	Total	1	1	1	1

Note: CU: Coastal Uses HC: Habitat Conservation - SA: Sea Access & Anchoring - WR: Water Recreation - BA: Beach Activity - AF: Artisanal Fishing

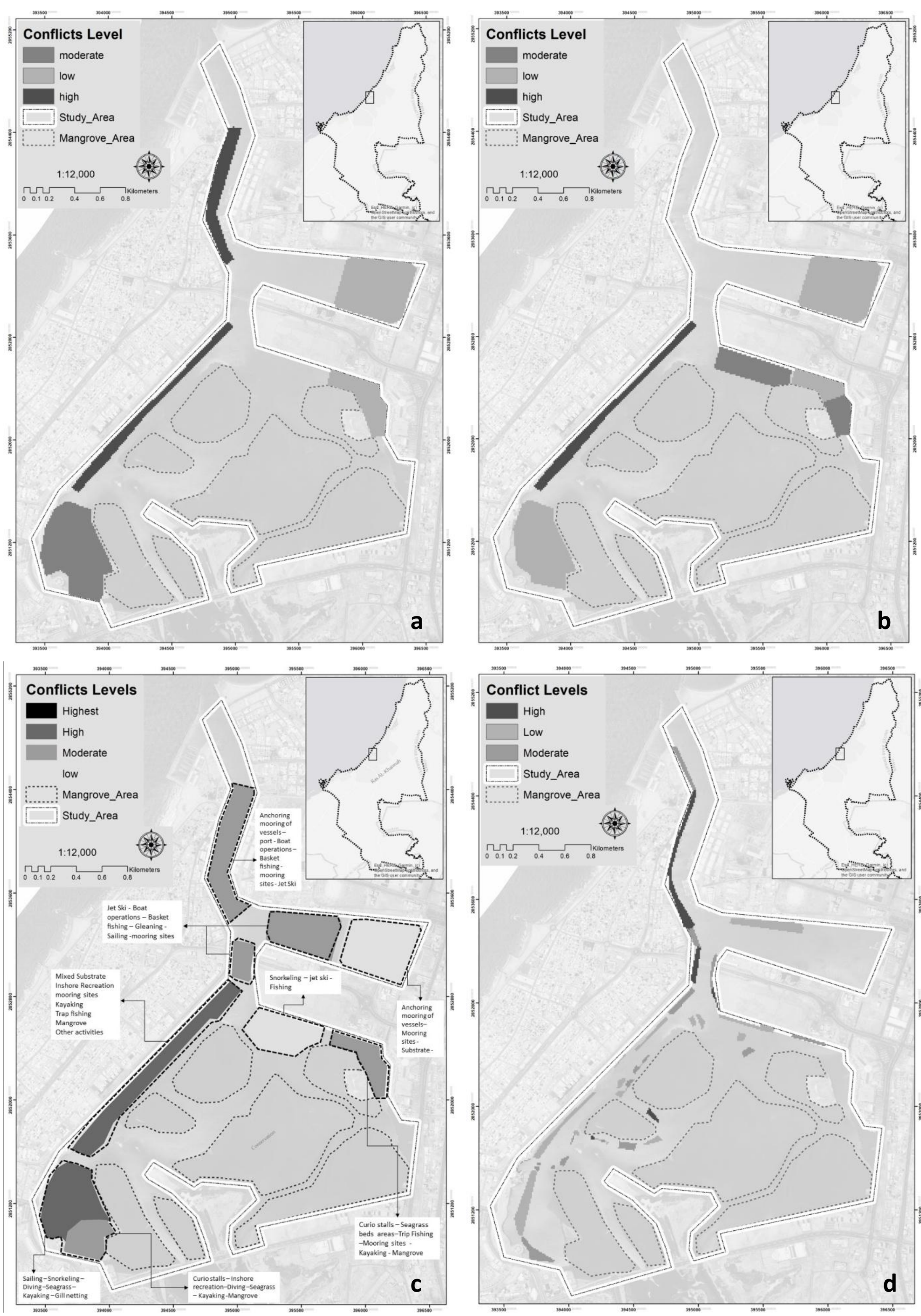

Figure 4. Map output showing conflict levels under current use (a) and three management scenarios: (b) Fisheries; (c) Recreation and (d) Conservation.

2.5. Optimization marine zoning plan

An optimal marine zoning plan is considered here to be one that minimizes the levels of conflict between different stakeholder values. An optimal spatial use pattern for a geographical location within the marine protected zone a particular conflict value is achieved by satisfying two goals: 1) selecting an activity or a combination of activities that will minimize the value to a level desired by the decision-maker; 2) allocating the total area optimally under a particular level of conflict to selected stakeholder values or activities.

A marine zoning plan is applied to identify the optimal marine protected area with human activity use patterns. The MZP was designed to ensure that all habitats are selected, and any conflicting stakeholder values that conflict intensely are not selected. As well as, helps to select stakeholder values based on their contribution to the overall conflict score subject to a set of constraints and assumptions imposed by the decision-maker and the spatial requirements. Two assumptions were considered: 1) the stakeholder values are selected for a particular location in the MZP according to their conflict scores in such a way that the higher the score, the less likely that the activity will be selected and; 2) conflicting uses, for example, beach seining and sailing, cannot be allocated to the same geographical location.

We were using the current conflicts location map, which we got as a result of a previous evaluation using GIS calculations. We classified all activities into three zones (Low – Moderate – High) based on related activities conflicts contribution in each zone. The identified activities in a conflict location in each zone were then used as variables for determining activity allocations for that location. The optimization marine zoning plan was formulated as 0-1 integer goal program (IGP) (Malczewski, 1999) where the variables represent two decisions of whether or not to allocate a specific activity to the conflict location. An optimal plan was agreed to be one that achieved the two objectives set out at the MCAM preparation stage, i.e. to minimize existing conflicts to the lowest level and to allocate space optimally to competing uses.

3. Results and discussion

The current conflicts in RAK Khor and Port area can be described as minimal and are localized in the lagoon areas. The analysis of environmental conflicts in the Khor for the four management scenarios reveals important trends. The conflict will arise whenever the activities of one stakeholder reduce the capability of the marine area for other stakeholders' activities. This study will help the RAK management address three important management issues: 1) identifying and mapping competing user values that are likely to cause spatial conflicts; 2) assessing user conflicts under changing future management directives; and 3) developing an optimal marine zoning plan.

The results of this study have shown that the current situation regime spatial conflicts are not at a critical level. Over 90% of the study area is under low and moderate level of conflict. Either these areas support ecologically sustainable use, and public recreation that is consistent with marine protected area objectives or users are not actively using these areas. The area designated as mangrove is under the lowest conflict because extractive activities like fishing are prohibited. Intense conflicts under the present, recreational and protection management scenarios are associated with the fisheries objective. Seining causes the highest level of conflict among the activities under the fisheries objective. Changing use patterns may result in intense conflicts spreading to other areas presently not under low levels of conflict. Any management interventions that change the marine area use patterns must be discussed carefully before implementation because the current conflict situation may be worsened. Current conflicts also need to be resolved otherwise; it may generate additional conflict in the future, therefore, limiting the efficiency or effectiveness of conservation measures. To achieve optimal use devoid of conflict, some stakeholder activities have to stop in specific locations. For conflicts to be minimized completely under the present management status, Seining and Jet Ski has to be eradicated or only allowed to continue in areas where no other uses occur. Areas used for snorkelling and sailing should also be re-designated in reserve.

Spatial conflicts in the Khor and port area have existed for a long time. However, there is no formal conflict-resolution mechanism that operates impartially and represents all stakeholders' interests equally. Instead, conflicts emerge and are generally addressed on an ad-hoc basis or ignored until they reach a crisis point. The methodological approach applied in this study intends to address this gap by developing a multi-criteria planning model that incorporates users' conflicts and critical ecosystems into a multi-objective decision-making framework. It provides a flexible way of dealing with the problem of conflicts in marine areas.

The approach allows for the integration of stakeholders in different ways: in data collection and in assigning a weight of importance to activities. The stakeholder activities used in this study are by no means exhaustive. Other interest groups, like researchers who have been monitoring sites in the marine areas and the Port Authority who have an interest in shipping routes, were not considered. Stakeholder participation in this study was incredibly helpful in defining the objectives and attributes and eliciting the preferences of stakeholders. Incorporating more stakeholders in this analysis is likely to improve the chances of success in achieving marine spatial goals significantly. Using this method in a collaborative context, where different stakeholders can understand how their interests related to specific locations and where they might conflict with others, maybe it is the most effective application.

The main limitation of this approach is in the subjectivity introduced in the MCAM, particularly in the choice of criteria and relative weights and the verbal rankings given to conflict scores. The verbal ranking may not accurately represent the conflict situation on the ground. This process, however, helps the decision-maker in qualitatively describing the different locations of possible conflict and the levels of conflict. Despite the inherent limitations of the model, it is useful as a tool for tackling stakeholder conflict, and it facilitates informed decisions when planning for multiple marine objectives. This method answers vital elements that are required in conflict management: 1) information development and analysis; 2) conflict assessment (what are sources of conflict); and 3) strategy and procedural decision (Deciding upon the process for addressing conflict). It answers the questions: who, what, where, when and how. It, therefore, provides an essential step toward managing stakeholder conflicts in the marine areas and integrating conflicting objectives in a decision framework. The accuracy and usefulness of this study would be enhanced by involving all stakeholders in the initial mapping of attributes and the validation of the graphic results.

4. Conclusion

This developed an MCAM methodology for environmental conflict management in the RAK Khor and port area in Ras Al-Khaimah, Emirate. An increase in the competitiveness of marine activities can lead to more spatial conflicts such as those in Khor and port area. The effectiveness of the MCAM in achieving its objectives can be hampered by existing stakeholder conflicts.

The multitude of sometimes-conflicting resource uses and activities require more elaborate and systematic planning. This study is an important contribution as it provides a methodological approach that can be applied in managing marine and coastal activity conflicts whilst simultaneously maximizing ecosystem gains. Spatial conflict analysis can be used proactively to understand the degree of controversy and use it to develop planning accordingly. It is essential that potential conflicts be assessed to anticipate and reduce unnecessary conflicts before they occur. Locating exactly where conflict hotspots are likely to emerge in response to changes in management policy can alert policymakers and enable them to avoid those areas or to design a process that includes conflict management. Marine and coastal spatial planning are crucial for the optimal and sustainable use of marine and coastal resources from economic, social and ecological perspectives. The methodology employed in this study may be useful in establishing rules of allocation of resources between conflicting uses and therefore help in conflict avoidance. Mapping environmental conflicts can be used as a tool that can guide planners to make informed policy decisions with economic, social and ecological objectives in mind.

This working framework can be developed as an application in the future that will simplify processes between involved parties and empower this application to be quickly incorporated into any form of government through an interactive online platform. Most of the future trends are about strengthening governance processes by establishing unified electronic systems that facilitate decision-making by decision-makers and stakeholders and avoid lengthy work periods to take a specific decision.

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