



Determination of environmentally sensitive zones along Persian Gulf coastlines through geographic information system

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Abstract

Integrated management of south coastline develops a long-term and sustainable strategy on the south coast protection regarding to sustainable development and comprehensive view through national strategies, as well as international commitments. This study was investigated to achieve the above-mentioned aims and practical plans in Hormozgan coasts in the northern of Persian Gulf. It also identified the protection and utilization of sensitive regions, sensitive amount, as well as new methods of land use and protected area maps with geographic information system. In Agenda 21 and the other Rio documents, it was also recommended to the governments to prioritize the protective measures and detections related to sensitive zones such as protected area, estuaries, mangrove forests, etc. For this purpose, eight images prepared by land set satellite and ERMAPPER software due to geometrical correction were used. Subdividing the region into 21 evaluation sub-zones and using 32 environmental sensitivity determination criterion, as well as ecological factors and existing uses based on an integrated management, monitoring process of the region has been studied. Then, each criterion was classified based on the universal experiences and with respect to the type, amount and preference of sensitive sources of coastal zone. The land use of the study area and detection of sensitive zones were outlined to address the ecological indices. The existing land is used based on integrated management of coasts, regional monitoring through field studies and data documentation. The results indicated that achieving optimum land use planning should be implemented through potential monitoring and determining the rate of sensitivity. Thus, except the protected areas, almost other coastal regions are not of great significance with regard to protection values and are classified as low to medium sensitive areas.

Key words: Sustainable development, land use, integrated management, study area, ecological factors.

Introduction

The area of Hormozgan Province is around 66,709.5 km² and located in the northern of the Persian Gulf in the southern of Iran (Fig. 1). This region is 4% of the wide area of Iran ⁷. The Province has 26 islands located in water area and 900 km of coastline length. The length of water border is promoted to 1400 km and includes the richest wetland systems of marine and coast ecosystems, estuaries, bays, coral reefs, tidal zones, marine meadows and mangrove forests, which are affected by pollutants accumulation and potential threats ¹⁵. These challenges are due to social-economic development in coastline and watershed basins and also affect directly sensitive regions and coast habitats ⁵. It has grown even further in economic and social status for feeding, transportation, energy and recreation at national and regional levels ³. These specifications cause to centralize related service complexes and develop this matter close to coastal zones ¹⁶. In fact, these activities have come to damage natural forms and unique habitats of coasts ¹². The legislative management plan for coastlines due to sustainable protection of environmental value and land use determination should be considered primarily as one of the

most significant executive parts of integrated management plan ¹⁰. The final goal of the whole activities of related studies and land use maps for sensitive areas tends to attract more and more attention from policymakers in order to make decisions and strategies ². Mal-functioning and incorrect adjustment of the infra-sectional plans and comprehensive management are important causes to exacerbate the problems of the coast and existing law and regulations ⁶. Application of GIS in preparing land use and protection area maps (under control of DOE) has extended the fine optimum application ¹⁴ which removes the current challenges through the sensitivity zoning of coasts ¹⁷. This study has been performed in Hormozgan Province at the Persian Gulf region in 2007.

Materials and Methods

Regarding the sensitive coastline of Hormozgan Province and based on recognition criteria of IMO, IUCN and ICZM (Table 1), as well as providing sensitive ranking map in coastal-rural districts, this research was carried out by the following methods.

Table 1. Sensitive area criteria for the Persian Gulf coastlines.

No.	Main criteria	Criteria sectoral	Low Score	High Score
1	Biogeographic criteria	-	0	5
2	Virgin	-	0	5
3	Unique	-	1	5
4	Dependence	-	1	5
5	Habitat	Habitat value	0	5
6		Habitat diversity	1	5
7		Habitat expanse	1	5
8		Habitat integrity diversity	1	5
9	Aquatics	Diversity	1	5
10		Extincted	0	5
11		Endangered	0	5
12		Spawning	0	5
13		Orphanage	0	5
14		Endangered	0	5
15		Extincted	0	5
16		Birds	Population	0
17	Marin turtles	Diversity	0	5
18		Generate	0	5
19	Marin mammals	Breeding	0	5
20		Feed	0	5
21	Protection procedure	-	0	5
22		-	1	5
23	Human dependence	Utilization	1	5
24		Economic value	1	5
25		Recreational value	1	5
26		Tourism Facilities	1	5
27	Recreation	Aesthetic	1	5
28		Historic and cultural monuments	0	5
29	Education	-	1	5
30	Research and monitoring	-	1	5
31	Threat factors	Group A	1	5
32		Group B	1	5
Total	15	23		160

Field study: Coastal investigation was done in rural districts. Determination of geographic situation by GPS included site selection of coastal sensitive zones, mangrove forests, threatening focal points under expert supervision and registration of geographical points to provide data layer. (Threatening focal points can be classified into two groups: Group A: Industrial pollution, oil materials discharge, agricultural pollution, unauthorized exploitation and Group B: Household pollution, overgrazing, drainage, road establishment, breeding, irregular utilization of aquatic animals).

Preparation of documented and basic information through GIS:

The study area (Fig. 2) was determined with regard to technical and surveying basis (based on satellite information in GIS). Information management and maps digitalization was done through Arc-view and Arc-GIS software. ERMAPPER software was used for special features, geometric correction of satellite images and proper rotation in order to integrate all figures of coastal-rural districts with the method of indicator points in geographical maps and satellite images, as well as correcting the images (RMS) ⁹. Habitats were documented throughout the study area by introducing site selection of protected area through geographical maps, expert analysis and registration of new points by GPS. Map was prepared for protected areas at the coastline of the province through producing and integrating data layers of protected area in Arc-view software ¹¹. Coastal land use map was prepared based on existing data. Coastal zones and sensitivity ranking maps were prepared.

Then, using ETM images prepared by land set satellite (after geometric correction) 7 bands were joined to each image through false color composite. The amount of existing layers was studied through unsupervised classification method and using bands 4 (infrared), 3 (red) and 2 (green). Given the classification numbers, current applications from field surveys associated with identifying points feature (GPS) and different uses will be put on images within classified method and learning patterns were created at proper distribution. Finally, it is important to prepare and present different land use maps such as pastures, forests and bushes, water, manmade regions and settlements, uncovered lands, coastal sands and riverbanks, as well as those, which combine above matters of land use map in coastal zone of Hormozgan province.

Determination of sensitivity degree based on selected evaluation criteria:

In this research, 15 major and 23 minor criteria were determined as sensitivity degrees, which were used in the Persian Gulf coasts for the first time. Quantitative value due to limited domain was also considered using descriptive criteria which have profits such as simplified application (because of current field data), as well as sophisticated deductions (Table 1). This method is more preferable than the similar other methods. The possibilities for comparison of similar regions and complicating of protected areas network is considerable. Tables 2-7 indicate the indices of several important criteria and the related scores.

Table 2. Biogeography criteria of sensitive areas.

Criteria	Index	Score
Biogeography criteria	The region without any unique quality biogeographic criteria	0
	The region with 1 unique quality biogeographic criteria	1
	The region with 2-3 unique quality biogeographic criteria	3
	The region with more than 3 unique quality biogeographic criteria	5

Table 3. Virgin criteria of sensitive areas.

Criteria	Index	Score
Virgin	Without changes in the condition of region	5
	With 1 -5 effective activities of human	3
	With 5-10 effective activities of human	2
	With 10-15 effective activities of human	1
	More than 15 Effective activities of human	0

Table 4. Unique criteria of sensitive areas.

Criteria	Index	Score
Unique	The coastal zone with 1 unique sample of international value resources	5
	The coastal zone with one of the few sample of international value resources	3
	The coastal zone with 1 unique sample of national value resources	2
	The coastal zone with one of the few sample of national value resources	1

Table 5. Dependence criteria of sensitive areas.

Criteria	Index	Score
Dependence	The coastal zone to be important for 10-20 protected commercial species	1
	The coastal zone to be important for 20-30 protected commercial species	3
	The coastal zone to be important for more than 30 protected commercial species	5

Table 6. Threat factors (Group A) of sensitive areas.

Criteria	Index	Score
Threat factors (Group A)	More than 3 threat factors are observed in the coastal zone	1
	2-3 threat factors are observed in the coastal zone	3
	10 threat factors are observed in the coastal zone	5

Table 7. Threat factors (Group B) of sensitive areas.

Criteria	Index	Score
Threat factors (Group B)	More than 10 threat factors are observed in the coastal zone	1
	5-10 threat factors are observed in the coastal zone	3
	Less than 5 threat factors are observed in the coastal zone	5

Results

Since there is no reliable and specific method to integrate the management pattern and optimum use of coastal zones, it is not trivial to recognize and introduce one area, as a coastal zone. However, based on studies, sensitive coastal zones should also be identified. Introduction of protected regions (Fig. 3) and determining the existing coastal land use (Fig. 4) in the study area play a very significant role.

This was carried out to create executive infrastructure of management due to sustainable development by two main objectives: 1) Preparing the most optimum land use map to integrate the management of the province coasts by virtue of confirmed data and documents; 2) Providing supervised rules and measures of the country law for each zones of optimum land use map.

Land use map for coastal zone of the study area is an important factor to achieve the sensitivity ranking use based on eight specialized studies, including related studies on settlement network, infrastructures, mine and industry/environment tourism, policy and security, pedology and agriculture at national and

regional levels. These areas should preserve environmental optimum land use and attempt to protect valuable biodiversity resources. There are not only protected ecologic resources but also marine tourism development. It should also be considered to recognize the unprotected areas within sensitive and valuable ecosystems as high value ecological zones. This pattern is based on systematic approach and information synthesis. Primarily, the coastal zone was divided on the basis of coastal-rural districts. Then, the numerical valuation of the criteria, whose amplitude and numerical value were described in previous section, was calculated for each geographic unit (Table 8). Therefore, the coastal zone was divided into 22 sub-zones or independent units (Fig. 5).

Considering the indices of every criterion, the divided units were analyzed based on scores allocated to each criterion. Following world experiences and performed evaluations based on the amount and type of sensitive resources in coastal areas, as well as criteria utilized by IUCN, the following classification has been used in order to introduce the rankings of every managed sub-zone within the coastal region:

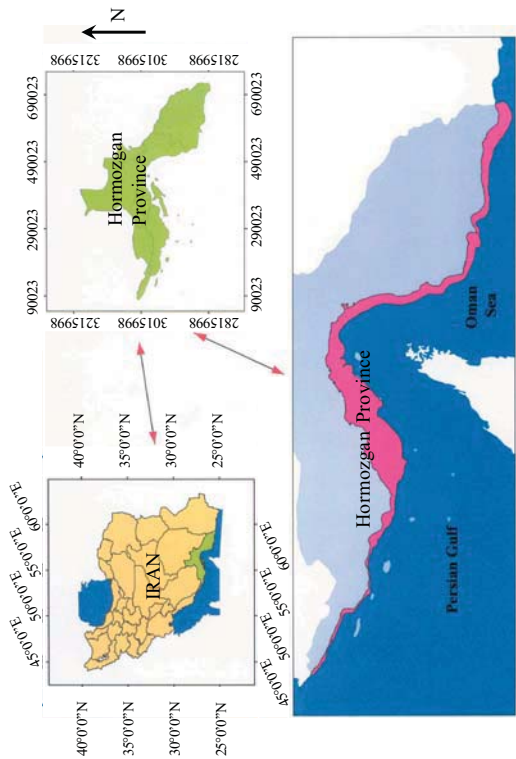


Figure 1. Geographical location of the study area (Hormozgan Province).

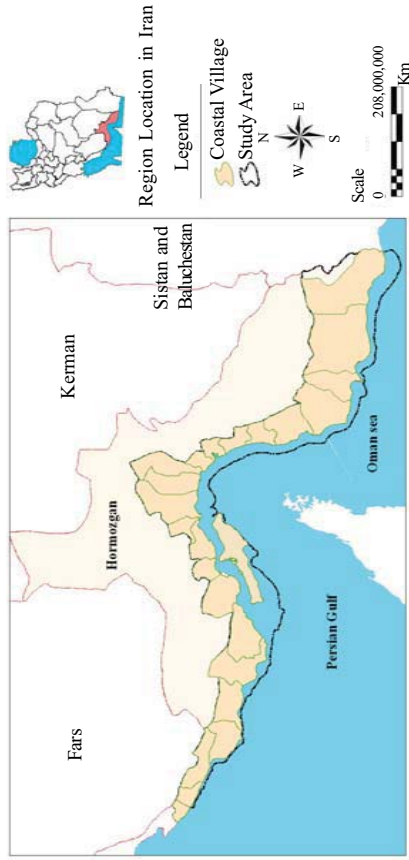


Figure 2. The coastline study area.

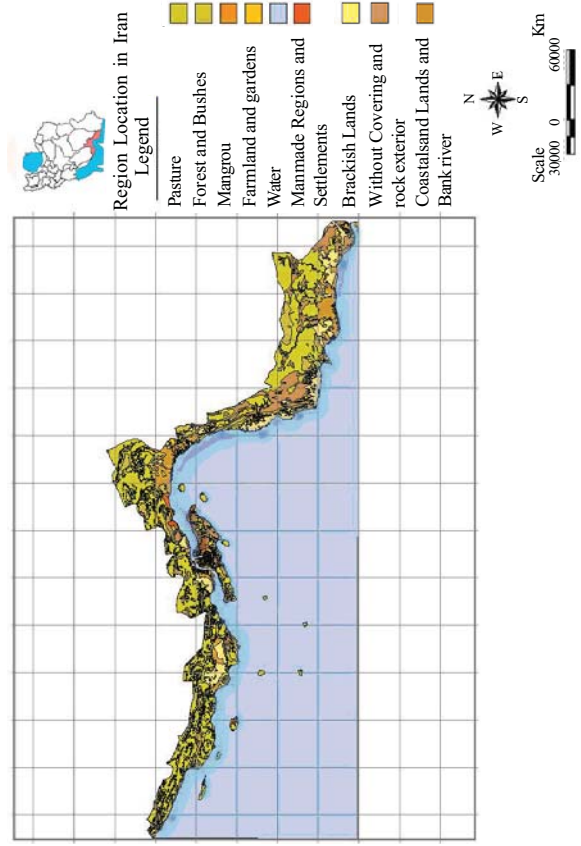


Figure 4. Land use map of coastal zones of Hormozgan Province.



Figure 3. Map of the sensitive regions.

Table 8. Scoring method of the sensitivity criteria.

No	Criteria	Zone 1	Zone 2	Zone 3	Zone 4	Zone 4	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11
1	Bio geographic	1	0	0	3	0	1	0	0	0	5	0
2	Virgin	3	3	3	3	2	2	2	3	3	2	2
3	Unique	1	0	0	2	0	0	0	2	2	0	0
4	Dependence	0	1	0	1	0	0	0	3	3	1	0
5	Habitat value	0	0	0	3	0	0	0	3	3	0	0
6	Habitat diversity	3	1	1	3	1	1	1	5	5	3	1
7	Habitat expanse	1	1	1	2	1	1	1	5	5	2	1
8	Habitat integrity	3	2	2	4	3	2	2	5	5	2	2
9	Diversity	0	1	0	1	1	0	1	5	5	1	1
10	Extinct	0	0	0	0	0	0	0	1	1	0	0
11	Endangered	1	1	1	1	1	1	1	1	1	1	1
12	Spawning	0	1	0	0	1	0	1	5	5	1	0
13	Orphanage	0	0	1	1	0	1	0	5	5	1	0
14	Endangered	0	0	0	0	0	0	0	5	5	0	0
15	Extinct	0	0	0	0	0	0	0	1	1	0	0
16	Population	0	0	0	0	0	0	3	5	5	3	0
17	Diversity	1	1	1	3	3	2	3	5	5	3	1
18	Generate	0	0	0	0	0	0	0	4	4	0	0
19	Breeding	0	0	0	0	0	0	0	0	0	0	0
20	Feed	0	0	0	0	0	0	0	3	3	0	0
21	Marin mammals	3	3	1	1	0	0	0	3	3	3	1
22	Protection procedure	0	0	0	4	4	0	0	5	5	0	0
23	Utilization	1	2	1	2	2	3	3	5	5	3	2
24	Economic value	1	1	1	3	3	1	1	5	5	1	1
25	Recreational value	1	1	1	3	3	1	1	5	5	1	1
26	Tourism facilities	1	1	1	1	1	1	1	3	3	3	1
27	Aesthetic	3	1	1	1	1	1	1	5	5	1	1
28	Historic and cultural monuments	0	0	0	0	0	0	0	3	0	0	0
29	Education	1	0	0	0	0	0	1	5	5	0	1
30	Research and monitoring	1	1	1	1	1	1	1	3	3	1	1
31	Threat factors, Group A	5	3	3	3	3	3	1	5	3	1	5
32	Threat factors, Group B	5	5	3	3	3	3	3	3	3	1	1
	Total	35	29	22	48	33	24	28	116	111	39	23

Table 8. Continue - Scoring method of the sensitivity criteria.

No	Criteria	Zone 12	Zone 13	Zone 14	Zone 15	Zone 16	Zone 17	Zone 18	Zone 19	Zone 20	Zone 21	Zone 22
1	Biogeographic	1	1	1	1	1	0	0	3	0	1	1
2	Virgin	1	2	5	3	3	3	3	5	3	3	5
3	Unique	2	2	0	1	1	0	0	2	0	0	2
4	Dependence	3	3	1	3	3	1	1	3	1	1	3
5	Habitat value	3	3	3	5	5	1	3	5	3	3	5
6	Habitat diversity	3	3	1	3	3	1	1	5	1	1	5
7	Habitat expanse	5	5	5	5	5	1	1	5	3	5	5
8	Habitat integrity	3	3	3	3	3	3	3	5	5	5	5
9	Diversity	3	3	1	3	3	1	3	3	3	3	3
10	Extincted	0	0	0	0	0	0	0	0	0	0	0
11	Endangered	†	†	0	0	0	0	0	0	0	0	0
12	Spawning	3	3	1	3	3	1	1	3	3	3	3
13	Orphanage	5	5	1	3	3	1	1	3	1	3	3
14	Endangered	5	5	0	0	2	0	0	2	0	2	2
15	Extincted	0	0	0	1	1	0	0	1	0	1	0
16	Population	3	3	4	4	4	0	0	4	0	1	4
17	Diversity	5	5	5	5	5	2	2	5	2	4	5
18	Generate	2	2	2	2	2	0	0	2	0	0	2
19	Breeding	0	0	0	0	0	0	0	0	0	0	0
20	Feed	0	0	1	1	1	0	0	1	0	0	1
21	Marin mammals	1	1	1	1	1	1	1	1	1	1	1
22	Protection procedure	5	5	5	5	5	0	0	5	0	4	4
23	Utilization	5	5	5	5	5	3	3	5	3	3	5
24	Economic value	3	3	3	3	3	3	3	3	3	3	3
25	Recreational value	3	3	3	3	3	3	3	3	3	3	3
26	Tourism facilities	1	1	1	1	1	1	1	1	1	1	1
27	Aesthetic	3	3	3	3	3	1	1	5	1	3	5
28	Historic and cultural monuments	0	0	0	0	0	0	0	0	0	0	0
29	Education	3	3	1	1	1	1	1	3	1	3	3
30	Research and monitoring	3	3	1	1	1	1	1	3	1	3	3
31	Threat factors Group A	3	3	1	1	1	2	2	2	2	1	1
32	Threat factors Group B	3	3	3	3	3	3	1	3	1	1	1
80	Total	80	81	61	73	75	32	34	91	40	62	84

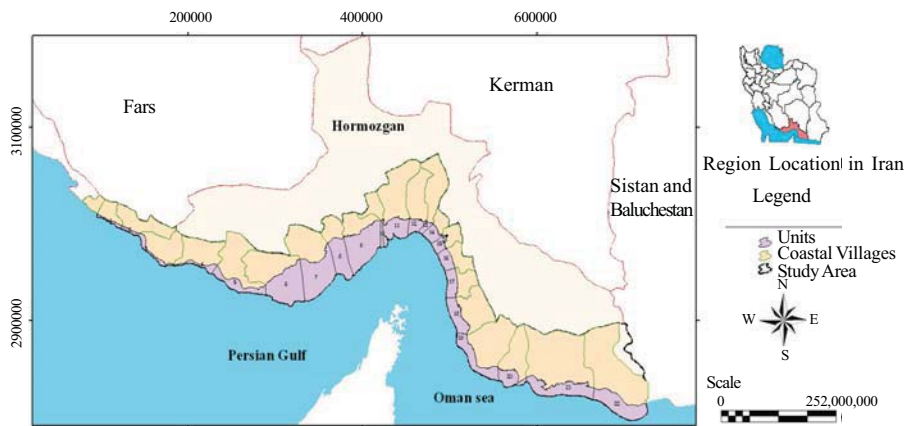


Figure 5. Subdivision of Hormozgan Province coastal zone.

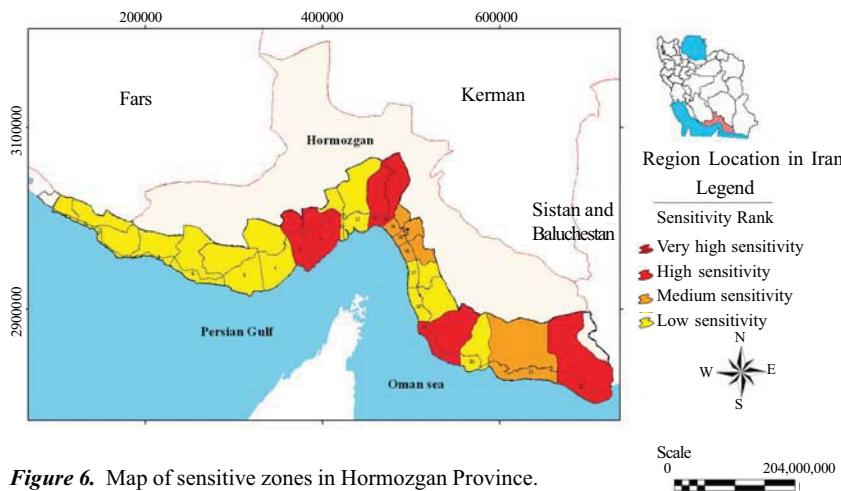


Figure 6. Map of sensitive zones in Hormozgan Province.

a. If the area is able to achieve 120-160 scores (more than 75 percentage of the total scores), it can achieve the most rate of the environmentally sensitivity (these areas can obtain the protective rank of the coastal - marine national park).

b. If the area is able to achieve 80-120 scores (50-75 percentage of the total scores), it is recognized as an area with high sensitivity (These areas can obtain the protective rank of the protected area of the coastal - marine or wildlife refuge).

c. If the area achieves 60-80 scores (30-50 percentage of the total scores), it can be considered as marine or coastal sensitive zone (medium sensitivity) (such area can be counted as a support for the development of the two mentioned areas). It can also be recognized as specific ecological regions whose regulations will be applicable to the same region.

d. If the area achieves less than 60 scores, it is called the area with low-sensitivity (these areas can be taken into consideration as open areas within the coastal districts). Although, such areas shall comply with rules and regulations of open areas, restrictions shall also be effective considering the survival of the protected species.

Following the above-mentioned subdivisions and scoring

procedures of the criteria, the map of sensitive zones is provided in Fig. 6.

Discussion and Conclusions

The present studies show that there are no specified, stable and reliable standard/criteria to identify coastal zone area and land use for countries⁴. In fact, each country uses specific index based on its situation. Current issues of the province's coastlines should have not only necessary coordination but also inter-related non-cancellation matters⁸. Lack of unity approach on human activities at the region and vulnerability of areas causes to increase day to day disrupting of ecological balance in sensitive areas, as well as consumption of excessive time and cost¹⁸. Environmental considerations limit unsustainable activities and focus on optimization and rational use through current resources of coastlines of Hormozgan. Thus, these have been mainstreamed in policy making and planning due to use of GIS. Based on the results, the whole coastal zone of Hormozgan Province in Persian Gulf is affected by Harra region¹. According to the results of environmental sensitivity evaluation analysis using 32 protection criteria, none of the 22 sub-zones along the coastlines of Hormozgan Province cannot be deemed as "very high sensitive" (Class 1) and therefore, will not be authorized to be classified as

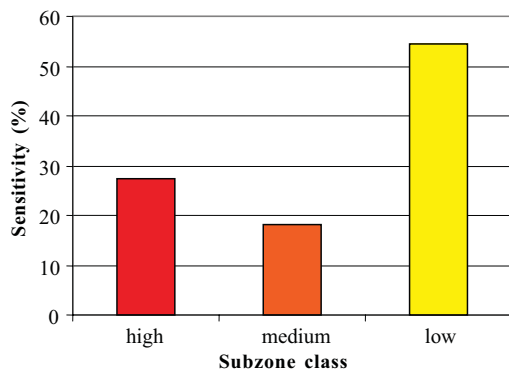


Figure 7. Sensitivity rankings of protected zones in Hormozgan Province.

coastline - marine national park. Only sub-zones 8, 9, 12, 13, 19 and 21 that comprise 27.27% of Hormozgan Province coastal area are classified as “high-sensitive” areas and the remaining lack any premium protection values and are classified as “medium and low sensitive” areas (Fig. 7).

The mentioned issues are among the essential matters of regional and global magnitude and it is necessary to apply integrated management system according to capacity, ecologic sensitive, land use and landform zoning¹⁹. Most of the countries will attempt to coordinate themselves with international trends and arrange their plans in coastal zones within low environmental damages¹³.

References

- ¹Baran, E. 1999. A review of quantified relationships between mangroves and coastal resources. *Phuket Marine Biology Centre Research Bulletin* **62**:57-64.
- ²Borja, A. 2004. Relationship between anchory, recruitment and the environment in the Bay of Biscay. *Scientia Marina* **8**(2):25-30.
- ³Burger, J. 2002. Tourism and ecosystem. In Douglas, I.(ed.). *Causes and Consequences of Global Climate Change. Encyclopedia of Global Environmental Change. Vol. 3.* Wiley, Chichester, pp. 597-609.
- ⁴Capobianco, M. 1999. EU Demonstration Programme on Integrated Management in Coastal Zones 1997-1999: Role and Use of Technologies in Relation to ICZM. Final Report, Tecnomare S. P. A., Venezia.
- ⁵Cicin, S. 2005. Sustainable development and integrated coastal management. *Ocean and Management* **3**(9):19-25.
- ⁶Clark, J. 2002. *Coastal Zone Management. Handbook.* New York, pp. 32-41.
- ⁷Danehkar, A. 2002. Sea sensitive areas of Iran and view of development. 5th International Conference on Coasts, Ports and Marine Structures (ICOPMAS), Ramsar, 14-17 October.
- ⁸Eleveld, M. A., Blok, S. T. and Bakx, J. P. G. 2000. Deriving relief of a coastal landscape with aerial video data. *International Journal of Remote Sensing* **21**(1):189-195.
- ⁹Flynn, L. P., Harris, A. J. L. and Wright, R. 2001. Improved identification of volcanic features using Landsat 7 ETM+. *Remote Sensing of Environment* **78**(1-2):180-193.
- ¹⁰Jan, P. 2003. Guide lines for integrated coastal zone management. *World Bank* **8**(9):65-72.
- ¹¹Jordan, R. L., Huneycutt, B. L. and Werner, M. 1995. The SIR- C/X-SAR Synthetic- Aperture Radar system. *IEEE Transactions on Geoscience and Remote Sensing* **33**(4):829-839.
- ¹²Karsten, M. 2005. Shore line management. *Guide Lines* **5**(4):50-55.
- ¹³Linda, B. 2003. Policy Instruments. ICZM, pp. 15-24.
- ¹⁴Lubin, D., Li, W., Dustan, P., Mazel, C.H. and Stamnes, K. T. 2001. Spectral signatures of coral reefs: Features from space. *Remote Sensing of Environment* **75**(1):127-137.

- ¹⁵Nouri, J., Danehkar, A. and Sharifipour, R. 2008. Evaluation of ecotourism potential in the northern coastline of the Persian Gulf. *Environ. Geol.* **55**:681-686.
- ¹⁶Pak, A. and Farajzadeh, M. 2007. Iran’s Integrated Coastal Management Plan: Persian Gulf, Oman Sea, and Southern Caspian Sea Coastlines. *Ocean & Coastal Management* **50**(9):754-773.
- ¹⁷Wright, R., Ray, S., Green, D. R. and Wood, M. 1998. Development of a GIS of the Moray Firth (Scotland, UK) and its application in environmental management (site selection for an ‘artificial reef’). *The Science of the Total Environment* **223**:65-76.
- ¹⁸Rycroft, M. J. 2000. From environmental risks, as problems, to Earth observations as solutions to those problems. *Surveys in Geophysics* **21**(2-3):115-125.
- ¹⁹US NEPA 1996. National Environmental Policy Act. Government Press, Washington DC.