JEB
Journal of Environmental Biology

Journal Website : www.jeb.co.in
E-mail : editor@jeb.co.in
ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Evaluation of comprehensive environmental effect about coastal zone development activities in Liaoning Province and management advice

Wang Wei-Wei*, Cai Yue-yin, Sun Yong-guang and MA Hong-Wei
National Marine Environment Monitoring Center, Dalian-116023, China
*Corresponding Author's Email : wwwang@nmemc.org.cn

Publication Info

Paper received:
11 June 2014

Revised received:
30 September 2014

Re-revised received:
01 January 2015

Accepted:
07 February 2015

Abstract

Using spatial analysis function of Arcgis software, the present study investigated the building environment impact evaluation index system of coastal development in Liaoning Province. The factors of it included of current state of environmental quality, environmental impact of marine development and marine environmental disaster. Weighted factor analysis and comprehensive index method were utilized. At the end, comprehensive environment effect of coastal development in Liaoning Province were evaluated successfully. The result showed that the environmental effect of development activity were most serious, along the Zhao Jiatun coast in north of Zhimao bay and coast of Mianhua island in Dalian bay.

Key words

AHP method, Coastal zone, Environmental effect, Liaoning province

Introduction

Spatial analysis of Arcgis has been widely used in species distribution evaluation (Mu *et al*., 2013), seismic hazards evaluation (Sevtap *etal*., 2012), land suitability evaluation (Chen *et al*., 2010), environmental pollution (Lubos *et al*., 2006) Delgado *et al*., 2010, groundwater vulnerability assessment (Aminreza *et al*., 2014) and environment influence evaluation (Qiu *et al*., 2007 (Lane *et al*., 2010), however, has scarcely been reported in environmental effect of development activities. This essay would employ AHP method (Saaty *et al*., 1980; Perry *et al*., 2008) to construct comprehensive carrying load evaluation index system. Spatial analysis is introduced to grid evaluation factors in space, according to their rank. Furthermore the environmental effect of Liaoning Province coastal development activities was evaluated and analyzed. The paper overcomes the weakness of equal-weight in direct superposition method (Wang *et al*., 2010), and is helpful in evaluating environmental effect of coastal development activities.

Materials and Methods

A comprehensive environmental effect of coastal development activities in Liaoning Province was evaluated. It can be divided into three elements; marine environment quality, environmental influence of sea developing activities and marine environmental disaster. The detailed evaluation route is shown in Fig1.

Liaoning Province sea area was dispersed into 100m× 100m grid areas, GIS spatial analysis was adopted to each element, influencing marine environment, to carry out spatial quantification. The environmental effect and marine environmental disasters were classified and assigned according to the level of influence on marine environment quality. After that, Delph method was applied to calculate the weight of each influence elements, and standardized assignment to each element (Wang *et al*., 2006; Xiong *etal*., 2007; Han *et al*., 2007). Eventually, comprehensive environmental effect formula was given below, was applied to calculate the level of environmental effect on each grid area.

$$I = \sum_{i=1}^{n} W_i x U_i \quad (1)$$

W_i indicates weights of each class index; $\sum_{i=1}^{n} W_i x U_i$, U_i indicates evaluation index for each class.

$$U_i = \sum_{j=1}^{n} (W_j x V_j) \quad (2)$$

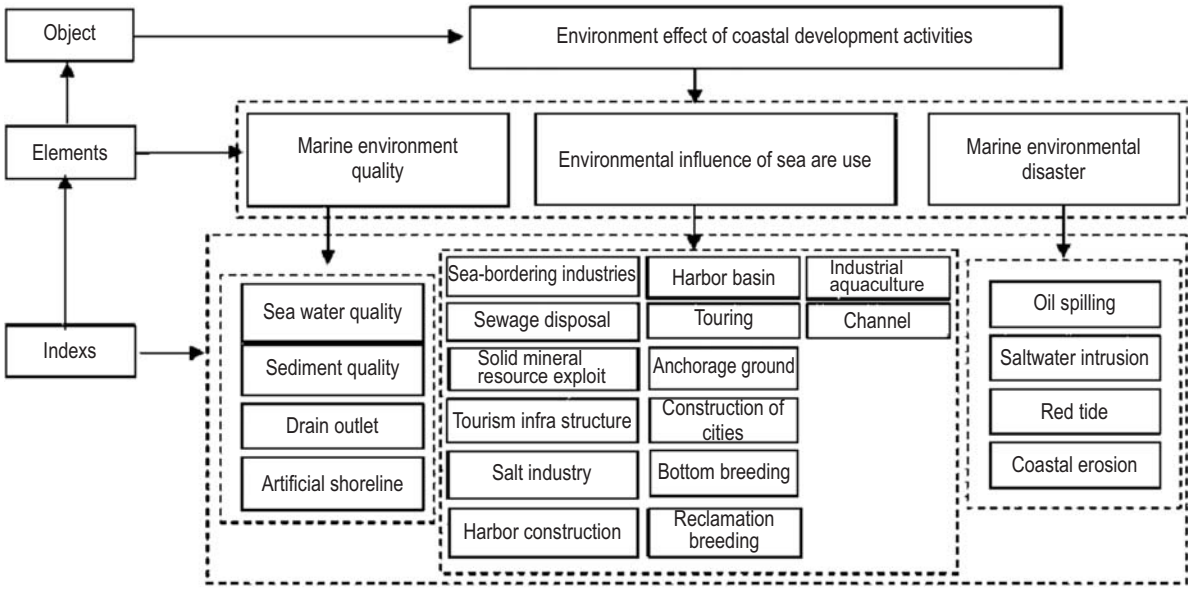

Fig. 1 : AHP analysis structure diagram

W_j indicates weight of each subclass index; $\sum_{i=1}^{n} (W_j \times V_j)$, V_i indicates evaluation index for each subclass. Composite indexes of Liaoning Province coastal development activities' environmental effects are shown in Table.1.

Marine environment quality consisted of sea water quality, artificial shoreline, sediment quality and drain outlet, in total four indexes. Control range could be confirmed according to sea water quality standard, and sea water quality standard could be divided into 5 levels. The environmental state of 4 water quality area was level 5; the environmental state of 4 water quality was level 4 and so on. Artificial shoreline's environmental influence was level 1, the controlling range of surrounding environment was 1km; sediment quality could be divided into 4 levels, 3-level sediment quality had influence 4km and so on. Drain outlet could be divided into 4 levels according to annual drain. Annual emission exceeded 1 million ton per year was the level 4, with an environmental control range of 4km; annual emission ranging between 0.1 to 1 million ton was level 3, with a control range of 3km; annual emission between 10 to 100 thousand ton was level 2, with a control range of 2km; annual emission less than10 thousand ton was level 1, with a control range of 1km.

Table. 1 : Composite index grading standards

Grading	Exponential value	Grading standard
1	0.5<I<0.7	Very serious
2	0.4<I<0.5	Serious
3	0.3<I<0.2	General
4	0.1<I<0.2	good
5	I<0.1	Very good

Environmental effect elements of sea developing activities consisted of sea-bordering industries, sewage disposal, fishery infrastructure, breeding facilities, harbor construction, bottom breeding, dumping, harbor basin, industrial aquaculture, solid mineral resource exploited, touring, channel, tourism infrastructure, anchorage ground, reclamation breeding, salt industry and construction of cities and towns, in total 17 indexes.

According to China's marine function zoning which gave strict marine environment requirements to different developing activities, 4 grades were set for marine environmental effects of different developing activities. The sea range controlled by maximum grade is not more 4 km. As one level goes down, correspondingly, controlling area range reduces 1 km. with completely or partly changing the nature of sea, the reclamation areas would construct a relatively closed marine environment. The areas had slight exchange with the exterior water body, restrained reproduction of marine species, and reduced self purification capacity of water quality and bottom materials. Therefore, the environmental influence of these marine activities would raise to a higher level. These activities mainly included of sea-bordering industries, fishery infrastructure, harbor construction, tourism infrastructure, salt industry and construction of cities and towns.

Coastal environmental disasters consisted of oil spilling, seawater intrusion, red tides and shoreline erosion. The control range could be confirmed according to coastal environmental disaster level. Oil spilling was on level 3, with a control range of

Table. 2 : The index system of comprehensive environment effect of development along the coast

Target	Factor	Index	Weight
	Marine environmental state 0.0999	Sea water quality	0.0405
		Sediment quality	0.0246
		Drain outlet	0.0191
		Artificial shoreline	0.0157
		Sea-bordering industries	0.0694
		Sewage disposal	0.0505
		Fishery infrastructure	0.0363
		Breeding facilities	0.0241
		Harbor construction	0.0603
		Bottom breeding	0.0229
Coastal zone development activities comprehensive effect evaluation	Multiple environmental effect of sea area use 0.646	Dumping	0.0499
		Harbor basin	0.0399
		Industrial aquaculture	0.0224
		Solid mineral resource exploit	0.0575
		Touring	0.0235
		Channel	0.0404
		Tourism infrastructure	0.0294
		Anchorage ground	0.0377
		Reclamation breeding	0.0229
		Salt industry	0.0304
		Construction of cities and towns	0.0297
	Coastal environmental disaster state 0.254	Oil silling	0.0872
		Saltwater intrusion	0.0554
		Red tide	0.0625
		Coastal erosion	0.0445

3km; level 2 disaster had a control range of 2 km and so on. Red tides disaster was on level 1, so the control range was 1km; seawater intrusion was on level 2, so the environmental influential capacity was set as level 2; Shoreline erosion was on level 5, with a control range of 5 km; disaster on level 4 had a control range of 4km and so on. Along with reduced disaster level, the control range also reduced.

Results and Discussion

On substituting weights of comprehensive environmental effect of coastal development activities influenced by sea water quality, sediment quality, drain outlet, and artificial shoreline, and corresponding environmental effect in formula 2, the evaluation result of marine environment quality was obtained, as shown in Fig.2. Areas with extremely miserable marine environment quality were mainly confined to southern of Jinzhou Bay, coastwise Daliao River to Shuangtaizi River, eastern and western sides of Dalian Bay, east of Dayao Bay, Dengsha estuary and Zhuanghe Bay. Areas with poor environmental quality were distributed in Jianzhou Bay on the top of Liaodong Bay to Daling River, coastwise Taiping angle, Dalian Bay, north coastwise Dengsha River, north of Zhuanghe Bay, Qingduizi Bay and south of Yalu River estuary, respectively.

On substituting the environmental effect comprehensive evaluation weight of coastal development activities in each sea area used elements and corresponding environmental effect level in formula 2, and the evaluation result of environmental effect of sea area use is shown in Fig.3. Various sea area use showed severe influence on Zhao village of Suizhong, Bayuquan, Mianhua Island of Dalian Bay, and Sikuaishi Island among Changshan Islands, and general influence on Zhujiakou on the eastern side of Jinzhou Bay, Xianren Island, Yangtouwa, Dayao Bay, XIngshu village, Dalayao, Black Island In Zhuang River and Yalu River estuary, respectively.

Coastal environmental disasters consist of oil spilling, sea water intrusion, red tides and coastal erosion. On substituting the environmental effect comprehensive evaluation weight of coastal development activities caused by coastal environmental disaster elements and corresponding environmental effect level in formula 2, the evaluation result of coastal environmental disaster effect was obtained as shown in Fig.4. Coastal environmental disaster had severe influence on Fudu estuary and Yalu River estuary, and general influence on Jinzhou Sunjia Bay, YIngkou Tianwaizi, sea area near Xianren Island and Dalian Bay.

On substituting 29 index weight of comprehensive environmental effect evaluation of coastal development activities and corresponding environmental effect levels in formula 1, comprehensive effect evaluation result of coastal development activities was obtained as shown in Fig. 5. The coastal development activities had severe environmental influence in

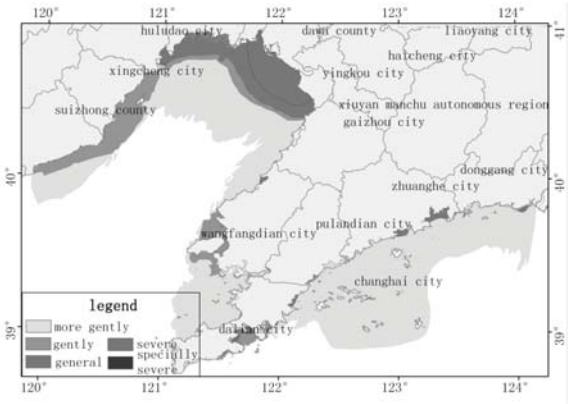

Fig. 2 : Evaluation of current marine environmental quality

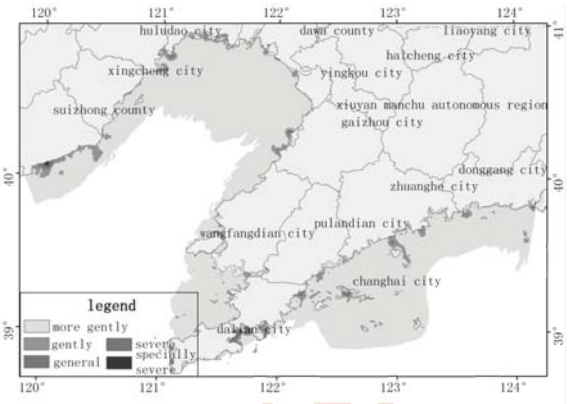

Fig. 3 : Evaluation of environment effect about various marine development activity types

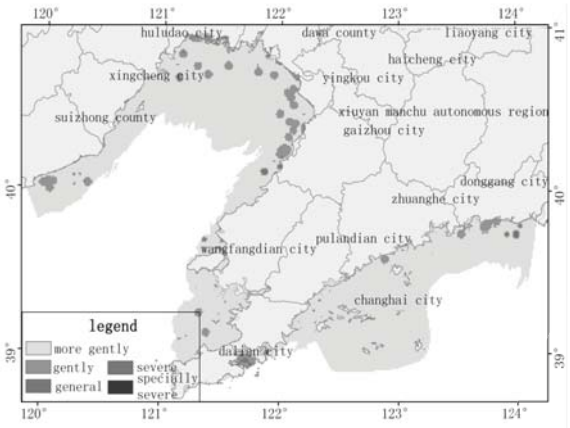

Fig. 4 : Evaluation of environment effect about coast zone disaster

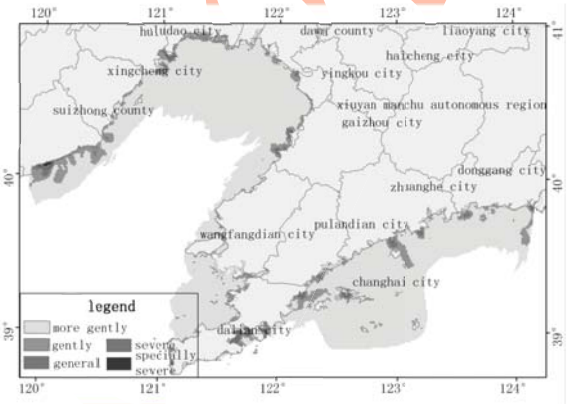

Fig. 5 : Evaluation of comprehensive environment effect about coastal zone development activities

Dazhao village on the northern area of Zhimao Bay in Suizhong, Mianhua Island in Dalian bay, about 21 sq km. Severe areas were distributed in Jinzhou Bay, Bayuquan Bay, Xianren Island Bay, Yangtou Bay, Dalian Bay, Dayao Bay, Xingshu Village, Dalayao, Black Island in Zhuang River, estuary of Yalu River and Sikuaishi Island among Changshan Archipelago, about 132 sq km. General areas were distributed along the southern side of Jinzhou Bay, Hulu Island bay, Daliao river estuary, Songmu Island, Xiaoyao Bay, bank near Pikou and Dayang estuary, about 345 sq km as shown in Table 3.

Coastal development activities had obvious influence on marine ecological environment of the surrounding waters; especially sea reclamation had direct influence. Till 2009, reclamation in Liaoning Province had reached an average of approximately 1797km^2. Massive reclamation and development activities occupied vast natural shoreline, tide passage ways of the bay and sea outlet, causing tremendous hazard to the marine ecological environment. In 2009, Liaoning Province reclamation occupied 1575 km natural shoreline, 251 km^2 bay areas that destroyed the ecological system of 104 islands (Wang *et al*., 2010). The environmental effect of frequent marine development activities cannot be ignored. Especially, the accumulative influences, which are apparent in sedimentary and biological pollutant load. In 1993, the water quality in Dalian Bay was already in polluted state. The main contaminants were inorganic nitrogen, oil and reactive phosphate (Wu,1993). From 2005 to 2007, the industrial waste water was mainly discharged into Dalian Bay, and emission load of three years was 343 million ton, 262 million ton and 262 million ton respectively. The sea water quality of Dalian Bay was at level 3; even level 4 during 2007, the main contamination were inorganic-nitrogen, phosphate and oil (Wang *et al*., 2011), as shown in Fig. 6. The massive reclamation activities and vast industrial water emission further aggravated water pollution in Dalian Bay.

The development activities in coastal zones and related environmental effect have multiple cause and effect relation. Sole development activity may generate diverse effects, and same environmental effect can be generated from multiple

Table 3 : Statistics comprehensive environment effect about coastal zone development activities

Environment effect grade	Sq (km^2)	Distribution zone	Environment effect grade of coastal zone development activities	Environment effect grade of coast disaster	Environment effect grade of marine environment state
Especially severe	21	Zhimao bay, Dalian bay	Especially severe	Severe/general	Severe/general
Severe	132	Jinzhou bay, Bayuquan port, Xianren island port, Yangtou port, Dalian bay, Dayao bay, Xingshu village, Dalayao, Black Island in Zhuang he, Estuary of yalu river and Sikuaishi Island among changshan archipelago	Severe	Severe / general	Severe / general
General	345	Along suizhong coast, Hulu island port, Daliao river estuary, Songmu island, Xiaoyao bay, Pikou longshore and dayang estuary	General	General	General / gently
Gently	1734	Liaodong bay and near shore in coastal zone of north yellow sea	Gently	Gently	General/gently
More gently	23145	Liaodong bay, near shore and shallow sea in north yellow sea	More gently	More gently/general	More gently

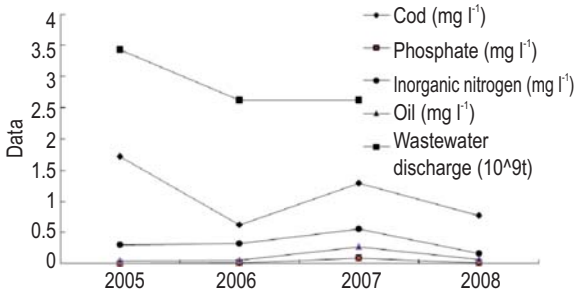

Fig. 6 : Statistic results distribution tendency chart of water quality

development activities, which is difficult to deal one by one (Mietton *et al*., 2007). What is for sure, is that human beings have brought serious negative effects or irreversible effects, on vulnerable coastal ecological environment by excessive development. Research on marine development activities aims at achieving protection and rational utilization of abundant resources of the coastal zones (Side *et al*., 2002; Read *et al*., 2003).

Arcgis space overlaying analysis proved to be applicable in evaluating comprehensive environmental effects of coastal developing activities. It is useful for us to evaluate the environmental effects of sea developing activities in future.

Acknowledgments

We would like to thank Professor Miao Fengmin for valuable advice. This work was supported by the Special investigation in Liaoning province.

References

Aminreza, N., B. Pradhan and M. Dadras: Groundwater vulnerability assessment using an improved DRASTIC method in GIS. *J. Reso. Conserv. Recy.*, **86**,74–86(2014).

Chen, Y., J. Yu and S. Khan: Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. *J. Environ. Model. Soft.*, **25**,1582-1591(2010).

Delgado, J., J.M. Nieto and T. Boski: Analysis of the spatial variation of heavy metals in the Guadiana Estuary sediments (SW Iberian Peninsula) based on GIS-mapping techniques. *J. Estuar. Coas. Shelf Sci.*, **88**,71-83(2010).

Han, J.W., W. Wu. and J. Li: Coastal zone sustainable development assessment. A case study of seven coastal cities of China. *J. Environ. Prote. Sci.*, **22**, 58-60(2007).

Lane, M.: The carrying capacity imperative: Assessing regional carrying capacity methodologies for sustainable land-use planning. *Land Use Policy*, **27**, 1038-1045 (2010) .

Lubos, M.E., E. Pavel and Z. Janour: A GIS-based approach to spatio-temporal analysis of environmental pollution in urban areas: A case study of Prague's environment extended by LIDAR data. *J. Ecolo. Model.*, **199**, 261–277(2006).

Mietton, M., D. Dumas, O. Hamerlynck, A. Coly and S. Duvail: Water management in the Senegal River Delta: a continuing uncertainty. *J. Hydrol. Earth Sys. Sci. Discus.*, **4**, 4297-4323 (2007).

Mu, J., N.J. Luo, W.Chang, K.Y. Huang and M.C. Shi: Predicting and mapping the spatial distribution of Chamaecyparis formosensis in central Taiwan in a GIS with species distribution models. *J. Acta Ecologica Sinica*, **33**, 325–331(2013).

Perry, R.I. and J.F. Schweigert: Primary productivity and the carrying capacity for herring in NE Pacific marine ecosystems. *Progress in Oceanography*, **77**,241-251(2008) .

Qiu, Y.F., Q.M. Qin, B. Cao. *et al*.: Sustainable development evaluation in coastal provinces in China based on GIS. *J. China Popul. Reso. Environ.*, **17**,69-72(2007).

Read, P. and F. Teresa: Management of environmental impacts of marine aquaculture in Europe. *J. Aquac.*, **226**, 139-163 (2003).

Saaty, T.L.: The analytic hierarchy process, planning, piority setting, resource allocation. McGraw-Hill, New York, (1980).

Sevtap, S.K.A., H.D. Sebnem and O. Lutfi: GIS-based software forlife line reliability analysis under seismic hazard. *J. Compu. Geosci.*, **42**, 37–46 (2012).

Side, J. and J. Paul: Technologies and their influence on future UK marine resource development and management. *J. Marine Policy*, **26**,231-241(2002).

Wang, W.W., P. Wang, Y.C. Wu and H.W. Ma: Environmental impact analysis of coastal exploitation in Dalian Bay. *J. Mari. Environ. Sci.*, **30**, 512-515 (2011).

Wang, W.W., P. Wang, Q. Zheng and H.W. Ma: Effect of reclamation activities on coastal ecologic environment in Liaoning Province. *J. Marine Environ. Sci.*, **29**, 927-929 (2010).

Wang, W.W., Y.B. Fu and F. Li: On the suitability of reclamation development of space resources in sea areas. *J. Ocean Develop. Manage.*, **27**, 5-8 (2010).

Wang Y.G., S.Y. Wu, L.J.Miao and Y.X. Song: Preliminary study on assessment method and index system of environmental effect of coastal zone development activity. *J. Coas. Engin.*, **25**, 63-70 (2006).

Wu, G.H.: Water pollution tendency of dalian bay. *J. Mari. Environ. Sci.*, **12**, 53-58 (1993).

Xiong, Z.Y.: Evaluation model and its application of the sustainable development of coastal zone, Beijing, China (2007).