Socio-Economic Spatial for the Sustainability of the Estuary Ecosystem in Pelabuhan Ratu Coastal West Java

Supriatna, L.[1,3], Supriatna, J.[2], Harmantyo, D.[3]

[1] Program Study of Enviromental Science, Universitas Indonesia.
  Jl. Salemba Raya No. 4, Jakarta 10430, Indonesia
[2] Departmen of Biology, Faculty of Matematics & Natural Science, Universitas Indonesia.
  Kampus UI Depok, Depok 16424, Indonesia
[3] Departmen of Geography, Faculty of Matematics & Natural Science, Universitas Indonesia.
  Kampus UI Depok, Depok 16424, Indonesia

E-mail: ysupris@yahoo.com;jatna.supriatna@gmail.com;djokoharmantyo@yahoo.com

Abstract. An estuary area is a typical ecosystem where a vast array of fish breed to enlarge populations. These regions are made productive by organic material in the form of foodstuff, while receiving sunlight sufficient enough to illuminate the brackish waters. These zones must be protected due to their fertile waters and surrounding fertile land. Estuary areas are threatened by nearby landfill and waste debris along and upstream of the river, which consequently contaminate the estuary zone. Socio-economic conditions of the community also affect the sustainability of the estuary. In this case, the Socio-Economic Spatial Model, based on Geographical Information System (GIS) and trade off analysis, were used to elaborate the ecosystem sustainability in the Cimandiri estuary, West Java. This research also uses the temporal analysis of land use change upstream and monitors the community activity around the estuary. The research showed a change in the spatial and temporal land use consequently altering the watershed and the socio-economic analysis showed the community use of the estuary as unsustainable for the region and ecosystems within.

Keywords : estuary, socio-economic, spatial, trade off, sustainability.

1. Introduction

Currently, the understanding of an *estuary* among society is limited, in particular the ways that a community directly uses an estuary. The activity of the community in the region can affect the estuary [1]. Population growth will pressure land area encroaching on the estuary and can affect the estuary ecosystems, which will ultimately lead to environmental degradation.

Regional planning usually emphasizes economic factors for the growth of its region rather than the balance of the environment factors, including the ecosystem balance [2]. The ecosystem, including the estuary ecosystem, can maintain the balance of surrounding environments. As it is said in the report of the World Commission on Environment and Development (WCED) about Our Common Future, sustainable development emphasizes the balance of social, economic and environmental spheres for future generations [3].

In order to properly conserve the estuary region and existing ecosystem, a holistic approach to consider social, economic and political factors is needed. The economic background of a community that uses an estuary as a main source of livelihood is a determinant of the degree of degradation in the region [4]. Community behaviour can directly or indirectly affect the surrounding ecosystem, in particular when the area is used irresponsibly for economic benefit, farmed incorrectly or waste is incorrectly disposed.

In their research, Fortini *et al.* [5] suggest that economic analysis can be used to focus on some of the advantages and disadvantages of timber production and *Acai oil* in the Amazon estuary and the phenomenons that arises from production activities. The result of the analysis was to draw up an alternative strategy to design better production, with consideration of economic, ecological and social impacts of production activities.

In a study area with a diverse range of estuaries, there is a trade off approach related to the social, economic and ecological factors affecting the estuary. The management of the fisheries sector as a whole becomes a big challenge, especially the conflicts of interest between socio-economic factors and the existing ecology in the estuarine area. An integrated model is needed with the approach of measuring the exchange (trade-off) between the ecological system and the socio-economic estuary systems [6]. Application of the trade-off method calculation in ecosystems (socio-ecological) depends on the results from assessment of the existing calculations [7]. The use of such methods reveal the fact that the values obtained are actual values. The use of the trade off method calculation and synergies for the ecosystem, in an industrial-oriented estuary region, reveals a relationship and mutual interest in sustainable estuary management measures [8].

The purpose of this study is to first examine the spatial use of estuary directly by the community, assess the existence of the estuary within the social and economic conditions of its community, and then evaluate the relationship of the estuary with the social and economic characteristics of the community. This is facilitated by the trade off analysis of the community by selecting the most important economic, social and ecological factors.

The simple and effective method to integrate spatial data from various sources can be quantified to make ecology and economy data area (zoning) in an estuary [9]. This model is integrating the spatial and tabular data to use traditional ecological and economic analysis. Similar research revealed the impact of the decline in production and consumption of Japanese eels (glass eel) in the Sagami estuary [10]. The decline had raised concern on the state of ecological decline and the factors of economic interests of the Sagami community.

An ecosystem-based model (economic and ecological factors) in the area of an estuary can be applied on an ongoing basis and act to majorly benefit the local community and surrounding areas. Not only in theory but in fruition, this model can create an investment in biodiversity and is not for certain specialties [11]. A more holistic and balanced approach needs to be taken on the policy framework of the beaches and coastal area in Indonesia [12]. The policy framework should be able to overcome the problem of vulnerability when addressing coastal communities on availability of marine resources. This research utilizes social, economic and government policies.

An economic-based model will give evidence that an interdisciplinary approach to a particular area can be done with management-based coastal area planning [11]. Cost approach methods allow integration of the most basic model of connectivity and activities to make certain planning areas in the city. The potential for this type of local planning in local decision-making process depends on the individual interests of planners rather than being systematic in nature [13].

A strong knowledge of management (production, mobilization, integration) is the key to achieving a sustainable socio-economic field to address the many challenges in the coastal area. For example, balancing the ecology, conservation and economic development of a region. The relationship between theory and practice with the socio-economic integrative approach requires involvement, participation, communication, and implementation between the community and the stakeholders [14]. The results of the social networks analysis have the potential to be a valuable tool in support of decision-making in conservation planning [15].

A collaboration is needed between the stakeholders and the government to protect (active conservation measures) and develop (development and investment) beach and estuary areas [16], [17], as well as benefiting the surrounding community [18]. In order to obtain a large amount of revenue through economic activity and to inspire people to be environmentally conscious, the collaboration between stakeholders and governments is a necessity.

Carvalho & Fidelis [19] stated that the institutional features of estuary management involve various agencies, stakeholders and users, as well as the principles of governance that are relevant. The result is a model of governance that is capable of ensuring the implementation of estuary planning, with a strong contribution to the involvement of all stakeholders and users in the planning of development. Thus, the conciliation of interests and active participation in decision-making need a firm place within the framework of collaborative governance.

In their research, Chen *et al.* [20] stated that the value of ecological functions is at risk and under pressure from estuary degradation and declining biodiversity. Also, Ottinger *et al.* [21] stated that the impact of anthropogenic activities on many estuaries has led to substantial changes in the surrounding environment.

The objective this research was socio-economic spatial and trade off analysis of the community activity around the estuary.

2. Methods

The following study of the socio-economic relationship between the community and the estuary used spatial analysis and trade off analysis. This research was carried out from June to December 2015. The study area is the estuary located in the area of Cimandiri [22] and the surrounding areas, which are on the South coast of West Java in the subdistrict of Simpenan and the Sukabumi Region.

The social and economic data on population was collected from the community living within and utilizing the resources of the Cimandiri estuary area. Population data sampling was arranged using the simple random sampling technique. Sampling is based on interviews with the community that directly utilize the Cimandiri estuary. This community (population) has approximately 1,200 people (Simpenan Sub-district, 2015). The majority of community members earn their living as sand miners and fish larvae fishers. Samples were taken from 200 respondents (which equates to 16.67% of the people who use the resources within the Cimandiri estuary). Out of the sample within the community 100 respondents were fish larvae fishers (eel) and 100 respondents were sand miners. The study was also carried out on a sample of stakeholders (community leaders and agencies related to the research theme) who were around the Cimandiri estuary area. The sample method was purposive sampling, utilizing interview techniques.

The variables of this study were determined by considering the presence of an estuary in conjunction with socio-economic aspects of the community, such as: education, employment, income, housing, knowledge and attitudes. The data processed included information regarding individuals living between Cimandiri Estuary and the community's shelters, all of whom directly utilize Cimandiri estuary. Socio-economic data is the knowledge and attitudes of the community towards the existence of the estuary. Socio-economic data is obtained by processing information to calculate social, economic and ecological trade off (profits and losses).

The relationship between the community who utilize the existence of the Cimandiri estuary and the estuary itself was analyzed using socio-economic analysis of the surrounding area. First, how far the influence of the Cimandiri estuary reaches in the surrounding area was analyzed. Second, the socio-economic conditions of local communities was analyzed and third, the social, economic and ecological trade offs were determined.

Spatial analysis was used to determine the region for study, that is, the region influenced by the estuary and the surrounding community. The radius for analysis was hence found to be the distance from the mouth of the River Cimandiri to the houses of the community members who directly use the Cimandiri estuary.

The study of tradeoffs (exchange) is one of the main principles of economics. People face a trade off between desires and the source of their desires. There is no issue if the source is unlimited and infinite, however when the source of their desire is limited a sacrifice is needed. This sacrifice is a trade off; giving up something that is liked to get something that is liked more. Analysis of trade-offs in managing various interests and desires should be done wisely [7], [8].

3. Result and discussion

The boundary of the Cimandiri estuary region for study was the area from the river mouth to the houses of community members who directly use the Cimandiri estuary. Figure 1 and Figure 2 show that fish larvae fishermen and sand miners live around the estuary of the Cimandiri River. Almost all of them reside in the five administrative regions of: Pelabuhanratu village, Jayanti village and Citarik village in the Pelabuhanratu district; Cidadap village and Loji village in the Simpenan district. The distance of community member's houses from the Cimandiri river estuary was less than 5 km.
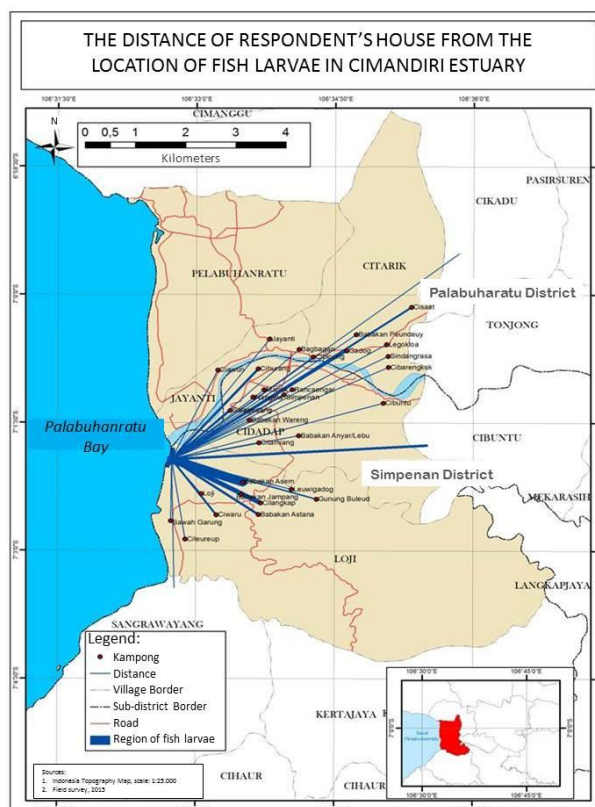

Figure 1: Map of the distance of respondent's' house from the location of fish larvae in Cimandiri estuary

Spatially, community member residences of the sand miners were an average distance of about 2.1 km from the Cimandiri estuary. There are nine hamlets in Cidadap village, four hamlets in Jayanti village, three hamlets in Loji village, two hamlets in Citarik village and two hamlets in Pelabuhanratu village.

Analysis of knowledge and behavior towards the Cimandiri estuary found the following:

a. All sand miner respondents (100%) are aware of the Cimandiri estuary, while the awareness of the fish larvae fisher respondents of the Cimandiri estuary is only 97%.

b. The importance of Cimandiri estuary for the sand miner respondents is 100% important while for fish fisher respondents is only 96% important.

c. 100% of sand miner respondents and 94% of fish larvae farmer respondents were aware that Cimandiri estuary is a habitat of fish larvae as a food for small fish.

d. The estuary of Cimandiri River is constantly deformed by the sediments carried by the river flow and big ocean currents (waves) that affects the formation of the estuary. 98% of sand miner respondents knew this, while 96% of fish larvae fisher respondents makers were aware.

e. The estuary of Cimandiri River must be protected from pollution, especially from the trash carried from the river upstream.98% of sand miner respondents and 85% of fish larvae fisher respondents were aware of this.
f. The changes in form of the estuary and pollution are due to human activity. 95% of sand miner respondents were aware of this and 72% of fish larvae fisherman respondents.
g. The river stream and Cimandiri estuary are always dirty, especially in rainy season. Respondents who knew this were 100% of sand miner respondents and 98% of the fish larvae fisher respondents.
h. Cimandiri estuary region is sometimes used for beach tourism activities (fishing in the estuary, taking fish larvae, and other tourist activities). Sand miner respondents who acknowledge this numbered 49%, while fish larvae farmer respondents numbered 66%.
i. The respondents are aware that the land around the estuary Cimandiri is fertile, which 98% of both sand miner respondents and fish larvae fisher respondents were aware of.
j. Estuary and beaches around Cimandiri are places for fishing. Both sand miner respondents and fish larvae fisher respondents are equally aware of this at 98% awareness.
k. The respondents who have ever utilized Cimandiri estuary are 100% of sand miner respondents and 98% of fish larvae fishermen.

From the results of the questionnaire, it appears that sand miner respondents are more aware of the Cimandiri estuary, showing that sand miner respondents were better educated about estuaries than respondents who farm fish larvae. More details can be seen in Table 1.

Table 1. The respondent percentage of the existence Cimandiri estuary

No	Respondent's knowledge and behavior	Respondent(%)	
		Fish Larvae	Sand
1	Perceiving the existence of Cimandiri estuary	100	97
2	The importance of Cimandiri estuary to the respondent	100	96
3	Respondents aware that the Cimandiri is a habitat for fish larvae as a food for small fishes	100	94
4	Cimandiri estuary constantly deformed by the sediments carried by the river flow and big ocean currents (waves) that also affect the formation of the estuary	98	96
5	Cimandiri estuary should be protected from pollution, especially the trash carried from upstream	98	95
6	Changes in the form estuary and the pollution occurred due to human activity	95	72
7	The stream and estuary are always dirty, especially the rainy season	100	98
8	Estuary area is sometimes used for beach tourism activities	49	66
9	The respondents aware that the surrounding land of the estuary is fertile	98	98
10	Estuary and beaches around the Cimandiri estuary is a place for fishing	98	98
11	The respondents have ever used the Cimandiri estuary	100	98

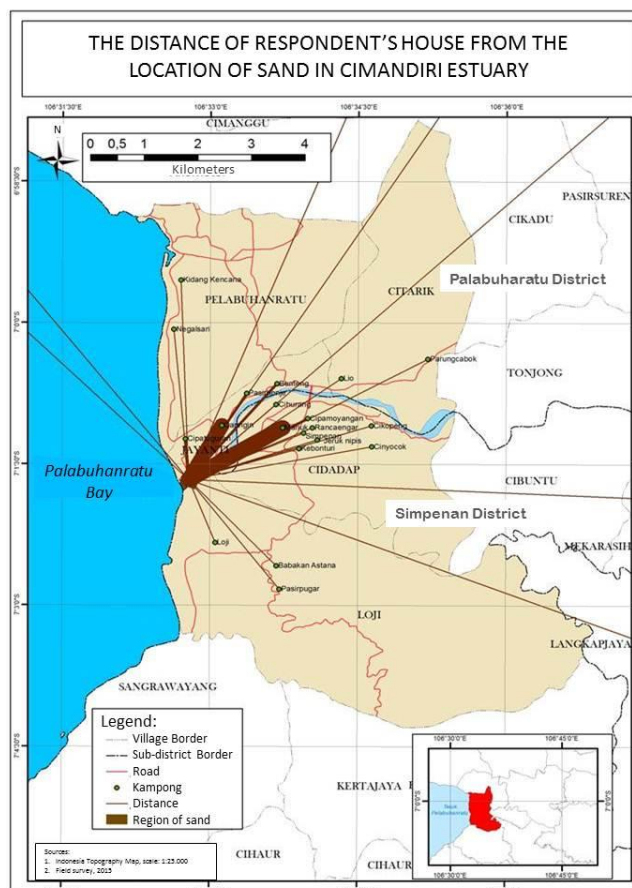Source: Field survey and data processing (2015)

Figure 2: Map of the distance of respondents' house from the location of the sand in Cimandiri estuary

The results of the analysis show that all of the public concern about the estuary in Cimandiri is mainly related to the conservation and protection of fish larvae. In most cases, public figures did not know about the regulations that related to the estuary, although some of them answer that they do know.

Socio-economic trade off analysis revealed that fish larvae fishers and sand miners with an average age of 40 years old think that taking fish larvae is not desirable, while respondents with an average age under 40 years old believe that taking fish larvae (eel) is a desirable job. Economic trade off analysis in the sand miner community shows that sand mining is a job that is desireable by respondents.

The next step was to synthesize the trade off approach to the social, economic and ecological analysis to derive policy alternatives in the model of sustainable landscape in the Cimandiri estuary. The stakeholder respondents comprised of the community that directly use the estuary, public figures around the estuary, and authorities that deal with estuary problems. Community as the main stakeholders (primary stakeholders), have a high level of concern for the estuary. The public figures around the estuary which is a second-tier stakeholder (secondary stakeholders) have a medium level of interest and influence on the decision-making process. Finally, government officials or authorities have the lowest interest levels but a high influence in the decision-making process [23].

Table 2. The criteria in determining the importance of estuaries.

Criteria	Sub criteria	Community	Public figure	Authorities
Social	Importance / benefit of estuary on surrounding communities.	98% answered that it is important.	100% answered that it is important.	100% answered that it is important.
	Estuary as a place to make a living in the surrounding communities.	98% answered as a place to make a living.	83% answered as a place to make a living.	90% answered as a place to make a living.
Economic	Community income from coastal tourism around the estuary	47% answered that the income is from tourism activities.	60% answered that the income is from tourism activities.	40% answered that the income is from tourism activities.
	Community income is from the estuary (fish larvae and sand).	97% answered that their income is from the fish larvae and sand.	80% answered that their income comes from the fish larvae and sand.	70% answered that their income comes from fish larvae and sand.
Ecological	Perceiving the estuary as a habitat for small fish	96% answered that estuary is a habitat for small fish	100% answered that estuary is a habitat for small fish	100% answered that estuary is a habitat for small fish
	Estuary must be protected from pollution	97% answered that it is must be protected.	100% answered that it is must be protected.	100% answered that it is must be protected.

Source: Data processing (2015)

Table 2 shown that 98% of community answered that they saw the estuary is a place to make a living and so be beneficial for the community. Even public figures (100%) answered that the estuary is important to the community for them to take the advantage of it, and 83% said that the estuary is the livelihood for the community.

Of the economic criteria, community's income from tourism activities apparently doesn't provide a significant income compared to larvae of fish and sand. The questionnaires result shown that 97% (community), 80% (the public figures) and 70% (authorities) answered the income of local communities comes from taking fish larvae and sand mining. Ecological criteria on the habitat of small fish and the protected estuary revealled that all of the stakeholders answered above 95%. Ecological criteria were the highest criteria, where the stakeholders answered that the estuary must be protected. The synthesis is available in Table 3.

Table 3. The social economic relationship of community to the existence of estuary

• Fish larvae community.	• 70% of fishermen and farmers take fish larvae every day.
• Sand miners community.	• 95% of sand miners take the sand every day.
• socio-economic trade off in the community	• The job of fish larvae fishers is to take eels larvae (30% of the answer), while the job of sand miners is mining the sand (93% of the answer).
• ecological socio-economic trade off in the community	• Ecological criteria is the highest criteria, where the stakeholders selected protecting estuaries.

Source: Data processing (2015)

The community and their socio-economic relationship in this study emerged by using trade off analysis. Trade off analysis of livelihoods (employment) is performed by the community who directly use the Cimandiri estuary and trade off analysis by the stakeholder is performed with the social, economic and ecological aspects in Cimandiri estuary. The result of this research is contrary to the results of the research with the community behavior approach on the social, economic and political aspects within the estuaries [4]. The economic analysis was calculated by considering gains and losses [5], estimates of the potential costs of land use patterns, and scenarios [6]. The research by Kismartini [7] and Lopeza *et al.* [8] also used the trade off method but the study was not in the area of estuaries. Meanwhile, Jacobs *et al.* [8] and Wang *et al.* [6] have done research using the trade off method that took place in estuary areas but the research was in the sub-tropical area.

4. Conclusion

There is a very close relationship between the socio-economic life of the community and the Cimandiri estuary. The bond that the community has made results from either the direct or indirect use of the environment through practises such as fishing, sand mining and tourism. The results of the trade off analysis considering social, economic and ecological factors has shown that ecological criteria are the most important for stakeholders, compared to social, economic and the other criteria.

Rerefences

[1]   Clarke, D.W., Boyle, J.F., Chiverrell, R.C., Lariob, J., & Plater, A.J. 2014. A sediment record of barrier estuary behaviour at the mesoscale: Interpreting high-resolution particle size analysis. *Journal of Geomorphology,* 221, 51-68.

[2]   Guneroglu, N., Acar, C., Guneroglu, A., Dihkan, M., Karsli, F. 2015. Coastal land degradation and character assessmen.t of Southern Black Sea landscape. *Journal of Ocean & Coastal Management xxx* (2015), 1-8.

[3]   Musacchio, L.R. 2009. The scientific basis for the design of landscape sustainability: A conceptual framework for translational landscape research and practice of designed landscapes and the six Es of landscape sustainability. *Journal of Landscape Ecology*, 24, 993-1013.

[4]   McAuliffe, S. Potts, J. Canessa, R. 2014. Establishing attitude sand perceptions of recreational boat users based in the River Hamble Estuary, UK, towards Marine Conservation Zones. *Journal of Marine Policy,* 45, 98-107.

[5]   Fortini, L.B. & Carter, D.R. 2014. The economic viability of smallholder timber production under expanding acaí palm production in the Amazon Estuary. *Journal of Forest Economics* 20 223-235.

[6]   Wang, Y., Hua, J., Pan, H., Li, S., Failler, P. 2016. An integrated model for marine fishery management in the Pearl River Estuary: Linking socio-economic systems and ecosystems. *Journal of Marine Policy,* 64, 135-147.

[7]   Lópeza, B.M., Baggethun, E.G., Llorentea, M.G., Montesaa, C. 2014. Trade-offs across value-domains in ecosystem services assessment. *Journal of Social Ecological Indicators,* 37, 220- 228.

[8]   Jacobs, S., Wolfstein, K., Vandenbruwaene, W., Vrebos, D., Beauchard, O., Maris, T., Meire, P. 2015. Detecting ecosystem service trade-off sand synergies: A practice- oriented application in four industrialized estuaries . *Journal of Ecosystem Services,* 16, 378-389.

[9]   Souza, F.E.S. & Silva, C.A.R. 2011. Ecological and economic valuation of the Potengi estuary mangrove wetlands (NE, Brazil) using ancillary spatial data. *Journal of Coast Conservation,* 15, 195-206.

[10]   Aoyama, J., Shinoda, A., Yoshinaga, T., Tsukamoto, K. 2012. Late arrival of Anguilla japonica glass eels at the Sagami River estuary in two recent consecutive year classes: ecology and socio-economic impacts. *Journal of Fish Science* 78: 1195-1204.

[11]   Guimaraes, M.H., Sousa, C., Dentinho, T., Boski, T. 2014. Economic base model for the Guadiana estuary, Portugal an application for Integrated. *Journal of Coastal Zone Management Marine Policy,* 43, 63-70.

[12]   Schulte, D.F., Gorris, P., Baitoningsih, W., Adhuri, D.S., Ferse, S.C.A. 2015. Coastal livelihood vulnerability to marine resource degradation: A review of the Indonesian national coastal and marine policy framework. *Journal Marine Policy,* 52, 163-171.

[13] Huber, P.R., Shilling, F., Thorne, J.H., Greco, S.E. 2012. Municipal and regional habitat connectivity planning. *Journal of Landscape and Urban Planning,* 105, 15-26.

[14] Rodríguez, D.P., Giebels, D., de Jonge, V.N. 2014. Strengthening coastal zone management in the Wadden Sea by applying 'knowledge-practice interfaces. *Journal of Ocean & Coastal Management,* xxx, 1-12.

[15] Mills, M., Romero, J.G.A., Borland, K.V., Cohen, P., Pressey, R.L., Guerrero, A.M., Ernstson, H. 2014. Linking regional planning and local action: Towards using social network analysis in systematic conservation planning. *Journal of Biological Conservation,* 169, 6-13.

[16] Cayeiro, M.L.P., & Ruiz, J.A.C. 2015. Evaluation of a programme of integrated coastal zone management: The Ecoplata Programme (Uruguay). *Journal of Marine Policy,* 51, 527-535.

[17] Ernoul, L., & Johnson, A.W. 2015. Environmental discourses: Understanding the implications on ICZM protocol implementation in two Mediterranean deltas. *Journal of Ocean & Coastal Management,* 103, 97-108.

[18] Beeharry, Y., Chadee, T.M., Bokhoree, C. 2014. Policy Analysis for Performance Assessment of Integrated Coastal Zone Management Initiatives for Coastal Sustainability. *APCBEE Procedia,* 9, 30-35.

[19] Carvalho, T.M., & Fidélis, T. 2013. The relevance of governance models for estuary management plans. *Journal of Land Use Policy,* 34, 134- 145.

[20] Chen, Q., Liu, J. , Ho, K.C., Yang, Z. 2012. Development of a relative risk model for evaluating ecological risk of water environment in the Haihe River Basin estuary area. *Journal of Science of the Total Environment,* 420, 79-89.

[21] Ottinger, M., Kuenzer, C., Liu, G., Wang, S., Dech, S. 2013. Monitoring land cover dynamics in the Yellow River Delta from 1995 to 2010 based on Landsat 5 TM. *Journal of Applied Geography,* 44, 53-68.

[22] Supriatna, L., Supriatna, J., Koestoer, R.H., Takarina, N.D. (2016). Algorithm model for determination of Cimandiri Estuarine boundary using remote sensing. *AIP Conference Proceedings* 1729, 020079.

[23] Kismartini. 2004. Analisis trade-off sebagai alat analisis kebijakan publik. *Jurnal Dialogue,* 1 (3), 1-19.