A study on the development of automatic economic profit and loss calculation system for maritime boundary delimitation

G Kwak¹, K Kim¹ and Y Park

¹Dept. of Geoinformatic Engineering, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon, South Korea

Abstract. As the maritime boundary delimitation is important for the purpose of securing marine resources, in addition to the aspect of maritime security, interest in maritime boundary delimitation to help national benefits are increasing over the world. In Korea, the importance of maritime boundary delimitation with the neighbouring countries is also increasing in practice. The quantity of obtainable marine resources depending on maritime boundary acts as an important factor for maritime boundary delimitation. Accordingly, a study is required to calculate quantity of our obtainable marine resources depending on maritime boundary delimitation. This study intends to calculate obtainable marine resources depending on various maritime boundary scenarios insisted by several countries. It mainly aims at developing a GIS-based automation system to be utilized for decision making of the maritime boundary delimitation. For this target, it has designed a module using spatial analysis technique to automatically calculate profit and loss waters area of each country upon maritime boundary and another module to estimate economic profits and losses obtained by each country using the calculated waters area and pricing information of the marine resources. By linking both the designed modules, it has implemented an automatic economic profit and loss calculation system for the GIS-based maritime boundary delimitation. The system developed from this study automatically calculate quantity of the obtainable marine resources of a country for the maritime boundary to be added and created in the future. Thus, it is expected to support decision making for the maritime boundary negotiators.

1. Introduction

Exclusive Economic Zone (EEZ) allows the coastal states to exclusively govern and regulate the economic zone up to 200 nautical miles with the effectuation of the United Nations(UN) convention on the law of the sea (1994). It recognizes exclusive rights of the coastal states for all resources within 200 nautical miles. Accordingly, there are many competitions over the world to acquire EEZ as much as possible [1]. In case of Korea, it is one of those countries in the northeast Asia with a peninsula, a lot of distributed islands, gulfs, channels, etc., that suffer from agreement on maritime jurisdiction. If 200 nautical mile EEZs are insisted from base lines of the Korean peninsula and neighboring countries, overlapped EEZ problems occur on a lot of parts out of sea areas between individual countries. In addition, in the case of the East China Sea where EEZs of three countries are overlapped, it is estimated to have considerable reserves of marine resources, and thus it is an important problem for the neighboring countries to acquire maritime jurisdictions [2]. Especially, as competitions to acquire more maritime jurisdiction on the sea is an important issue for the purpose of acquiring marine resources in addition to a maritime security aspect, importance of the maritime boundary delimitation comes to the front in practice. Like this, how much a country is able to obtain marine resources depending on the maritime boundary upon negotiation of the maritime boundary acts as a main factor of consideration for maritime boundary delimitation [3]. As such, it is required to identify

¹To whom any correspondence should be addressed.
marine resources that a country is able to obtain for the maritime boundary to be established. This method really requires studies on economic analysis using several maritime boundaries insisted by individual countries. Accordingly, this study intends to develop a GIS-based automation system to extract waters areas of profit and loss for the maritime boundaries insisted by individual countries and calculate economic profit and loss using the extracted waters areas and marine resources that exist in the waters areas.

2. Automatic economic profit and loss calculation system design
As this study is to apply spatial data to the economic analysis system, it has designed the system by applying spatial analysis technique. The spatial analysis technique applied to the system design is a spatial area calculation technique using attribute table of spatial data, spatial data cutting and overlapped area extraction. For the modules designed using this spatial analysis technique, this study has designed total two stage modules consisting of automatic profit and loss area extraction module and automatic economic profit and loss calculation module.

![Figure 1. Method of profit and loss extract.](image)

2.1. Automatic profit and loss area extraction module
A method to extract automatic profit and loss areas applied with spatial data cutting technique is shown in Figure 1. It selects one of the Yellow Sea, the East China Sea or the East Sea around Korea and searches a maritime boundary scenario that exists in the waters area. After selecting, out of those searched, a maritime boundary scenario (standard scenario) to be the basis and another one (target scenario) to be compared respectively, it divides the relevant waters area using both scenarios. Split waters by both scenarios are set to the basic area and the target area. On the location of Korea, the basic area and the target area are set up differently depending on waters. Using these, it has been designed such that the profit surface becomes the area calculated from the basic surface of standard scenario with the target surface of target scenario removed, while the loss surface becomes the area calculated from the target surface of standard scenario with the basic surface of target scenario removed. Afterwards, it has been designed such that feature dataset can be created to store various spatial data to be used on this study. Feature Dataset includes several spatial data (feature class) and it is included in the Geodatabase. Especially, Geodatabase is a spatial DB format which is commonly used in ArcGIS product family from ESRI (Environmental Systems Research Institute) and has an advantage to allow efficient storage and management of the spatial data, it has been used for this study [4]. After creating feature dataset, the module has been configured so that both individual profit surface and loss surface should be stored as a feature class within the feature dataset.
2.2. Automatic economic profit and loss calculation module

A module has been developed to automatically extract economic profit and loss using profit surfaces, loss surfaces, marine resources distribution map including fishing species, minerals, etc. and pricing information within Geodatabase. This module extracted quantities of individual marine resources included in the profit surface and loss surface using the marine resources distribution map. It has been designed to calculate economic profit and loss through an operation of multiplying pricing information by the marine resources quantities using marine resources pricing information. This profit and loss calculation is repeated as many as the number of the marine resources, and the calculations are accumulated and added up. The entire processes of the automatic profit and loss area extraction module and the automatic economic profit and loss extraction module are shown in Figure 2.

![Figure 2. Diagram of automatic economic profit and loss calculation system.](image)

3. Automatic economic profit and loss calculation system implementation

In order to implement automatic economic profit and loss calculation system based on the designed modules, Microsoft VB.net language has been used and for GIS-based spatial analysis, ESRI ArcObjects has been used. Results of implemented system are shown in Figure 3. After selecting the relevant waters area, selecting the standard scenario and target scenario allows automatic division of the waters area to calculate the profit and loss areas. Marine resources included in the profit surface and the loss surface are extracted through the profit and loss areas, and marine resources are calculated through the automatic economic profit and loss calculation extraction module. In this process, the system has been implemented. The outputs for the marine resources have been visually displayed through quantitative numbers such as acquisition quantity, economic value, etc. and the profit and loss graph.
4. Conclusions
This study has designed modules to automatically divide the waters area by the maritime boundary, to extract the profit and loss areas and to automatically extract and calculate the marine resources only existing in the waters. After that, the automatic economic profit and loss calculation system was implemented by linking both designed modules. The developed modules enable immediate decision making support for the policy makers for the newly insisted maritime boundaries on negotiation of the maritime boundary delimitation. In addition, while there was an inconvenience to manually calculate profit and loss areas of the features within the feature class, it becomes possible to calculate estimated reserves fast and correctly through development of the automatic economic profit and loss calculation system. Furthermore, it is expected to be diversely utilized for many research areas requiring automatic area division for the spatial data.
Acknowledgments
This work was researched by the supporting project to educate GIS experts

References
[1] Eunji Park, Kyehyun Kim, Chulyoung Lee 2008 Development of GIS-based EEZ Policy making Support System, The Journal of Geographic Information System Association of Korea 183-188
[2] Hyunsoo Kim 2007 Legal Response to Japan's Claims on the Maritime Boundary Delimitation in the East China Sea between Korea and Japan, The Korean Society of International Law, 52 43-66.
[3] Youngmin Youn, Yuncheol Lee 2006 A Study on the Maritime Jurisdiction Policy and Maritime Boundary Delimitation of the states around the Korean Peninsula The Korean Society of Marine Engineering 135-136
[4] ESRI, 2011 Building Geodatabase(10.0) ESRI Korea