Chapter 45
Aggregating GIS and MCDM to Optimize Wave Energy Converters Location in Tasmania, Australia

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ABSTRACT

The aim of this chapter is to develop a framework to guide Wave Energy Converters (WECs) sites using the coastal waters of Tasmania as a case study. This chapter proposes a combined two-stage Multi-Criteria Decision Making (MCDM) methodology to determine suitable locations for WECs siting with overlapping and minimal conflicting uses. A methodology combining MCDM and Geographic Information Systems (GIS) was developed combining the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and the Analytical Hierarchy Process (AHP). Priority rankings for each of the human uses and ocean features were prioritized using AHP and were then applied to TOPSIS analyses. A chain of optimal locations were determined, stretching from the southwest to southeast coast of Tasmania, where presently low densities of human activities overlap with high wave height. The result shows that suitable areas for harnessing WECs may not always be located in the highest wave energy areas.

INTRODUCTION

Planning and management in the marine environment is an inherently complex process. Careful consideration of the complexity of human relationships with the marine environment, the provision of good and services the particular environment provides, and the interaction between competing uses and these goods and services, must be taken into account (Christie, Smyth, Barnes, & Elliott, 2014; Jentoft & Knol, 2014; Merrie & Olsson, 2014). In addition, strategic planning of new activities also needs to take into consideration all of these relationships, as well as the spatial extent and diversity of human uses.

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Confronted with a lack of data about the marine environment and human uses of this environment, marine resource manager are challenged with the difficult task of making management recommendations and planning decisions based on imprecise or subjective information (Carruthers et al., 2014; Francis, Nilsson, & Waruinge, 2002; Wright & Barlett, 2000). Soft computing techniques deal with the uncertainty and imprecision of information, and are a viable approach to support human decision making processes, such as marine spatial planning. Soft computing consists of a consortium of methodologies that work synergistically and provide flexible information processing capability for handling ambiguous decision making and provide a way of integrating expert knowledge in the decision making process (Zadeh, 1994, 1997). Expert knowledge can carry semantics and information about human use and environmental variable behaviour, which can be introduced through computing methods, to overcome imprecise and or subjective information in the decision making process. Multi criteria decision making methods, especially MCDM have made their way in to this field for several years. Among them, the analytical hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS) have been employed more than other techniques and methods have. This chapter considers the development of a framework to integrate expert knowledge into a process of marine spatial planning for optimizing the siting of wave energy conversion (WEC) devices. The framework is applied to a case study for optimize the siting of WEC devices in the coastal waters of Tasmania, Australia.

Ocean Wave Energy

Ocean wave energy is a promising source of electrical energy due to its high energy density (Pan, 2014). Global and national scales of wave energy resource estimation have been carried out by previous studies. Gunn and Stock-Williams (2012) calculated global wave power within 30 nautical miles offshore, and the results show that 4.6% of 2.11 ± 0.05 TW (95% confidence) world's wave energy resource are possibly extracted by a Pelamis WEC device. Many countries show interest in wave power, and assessments of energy resources for both regional and national extents have been conducted throughout Australia (Behrens, Hayward, Hemer, & Osman, 2012; CSIRO, 2012; Hughes & Heap, 2010), Asia (Chiu, Huang, & Tiao, 2013; G. Kim et al., 2012), Africa (Hammar, Ehnberg, Mavume, Cuamba, & Molander, 2012; Joubert & Niekerk, 2013), and Europe (Aydoğan, Ayat, & Yüksel, 2013; Barbariol, Benetazzo, Carniel, & Sclavo, 2013; Folley & Whittaker, 2009; Iglesias & Carballo, 2010; Rusu & C., 2012), and the US (Stopa et al., 2013). For instance, an assessment based on wave power analysis showed that the southern Australian shelf including South Australia, Victoria, Tasmania and southern Western Australia are potential locations for WECs (Hughes & Heap, 2010). In a study from the Pacific Northwest of the US, results show that the nominal significant wave height in the area has the potential to produce a reliable and sustainable resource of energy through the deployment of WECs (Lenee-Bluhm, Paasch, & Özkan-Haller, 2011).

Wave energy becomes more suitable for electricity supply when a large proportion of world's population live in coastal areas (Kay & Alder, 2005). Energy extraction from ocean waves has been studied in many countries such as the USA (Lenee-Bluhm et al., 2011), Australia (Behrens et al., 2012), and throughout Europe (Aydoğan et al., 2013; Iglesias & Carballo, 2010; Portilla, Sosa, & Cavaleri, 2013). In recent years, wave energy has become a more feasible alternative as the technology has improved and become more cost effective. The interest in wave power has recently expanded and there are a remarkable number of energy extraction devices that are being developed and tested around the world (Hayward & Osman, 2011).

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