## A Locational Decision Making Framework for Shipbreaking under Multiple Criteria

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#### ABSTRACT

The decision making process for shipbreaking is complicated and is dependent on multiple factors. However, due to the vastly unorganized nature of shipbreaking industry in major shipbreaking locations, there is little work done to the best of the authors' knowledge, wherein these factors are mapped, weighed and integrated in the form of a comprehensive decision making framework. In recent years, although there have been significant efforts by researchers to capture the process of shipbreaking and recycling in literature, a comprehensive decision support system that encapsulates the multiple criteria for shipbreaking in a quantifiable form, is yet to be developed. This paper attempts to bridge this gap, by formulating a decision making framework, particularly for selecting the shipbreaking facility and the extent of recycling subsequent to ship disassembly, using AHP methodology. The framework considers the relevant factors, and is useful not only for shipping companies and cash brokers for decision making, but also provides insights vis-à-vis the migrating pattern of shipbreaking industry, particularly from Indian subcontinent to China, as observed in the contemporary business environment.

#### **KEYWORDS**

Analytic Hierarchy Process, Decision Support System, Location Selection, Multi Criteria Decision Making, Shipbreaking, Strategic Decision Making

#### INTRODUCTION

Shipbreaking is a multi-billion dollar industry, flourishing largely in the developing Asian countries; particularly in India, Bangladesh, China and Pakistan (UNCTAD, 2012). The industry gained the attention of environmental activists, regulators, researchers and media during the recent years; environmental impact due to shipbreaking and dangerous working conditions for laborers in the shipbreaking yards of the third world, being the visible symptoms that raised the alarm, placing the industry in focus. With the subsequent microscopic scrutiny that followed, there have been several studies on shipbreaking and ship recycling activities around the world, with special attention on yards

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in the Indian Subcontinent, i.e. Alang-Sosiya Ship Recycling Yard (Gujarat, India) and Chittagong Ship Breaking Yard (Bangladesh), which accounted for the bulk of global shipbreaking in the last two decades. Due to the largely unexplored nature of the shipbreaking industry, most of the pilot research studies conducted in recent years, are predominantly qualitative in nature, concentrating on process mapping (Asolekar, 2006, 2012; Demaria, 2010; Hiremath et al., 2015; Hossain & Islam, 2006; Hossain et al., 2010; Pelsy, 2008; Sivaprasad, 2010; Thomas 2007; Upadhyay 2002); with few studies on social & environmental impact assessment (Islam & Hossain, 1986; Pathak, 1997; Reddy et al., 2003, 2004a, 2005a 2005b; Sonak et al., 2008), and developing methodological frameworks for shipbreaking industry (Carvalho et al., 2009; Huang, 2010). A taxonomic listing of relevant research papers on shipbreaking is represented in Table 1.

While the extant literature, listed in Table 1, captures the qualitative aspects of shipbreaking, primarily through empirical research and case studies, there is little work done in developing a comprehensive framework for fleet managers (or superintendents representing owners of shipping companies) that aids the strategic location decision making for shipbreaking. Although there have

Classification	Author (Year)	Notes	Study Location
Qualitative	Anderson (2001) Asolekar (2006) Asolekar (2012) Demaria (2010) Dev (2010) Gökdeniz et al. (2008) Hiremath et al. (2015) Sonak et al. (2008) Hossain & Islam (2006) Hossain et al. (2010) Sivaprasad (2010) Upadhyay (2002) Xiangli (2007)	Worker safety in ship breaking Solid Waste generation during shipbreaking Greening of Shipbreaking – Facility Upgrade Economics of waste disposal in shipbreaking Prospects for sound ship recycling Shipbreaking: Health & Environmental issues Significant steps in ship waste recycling Implications of shipping hazardous wastes Impact of shipbreaking on coastal zones Recent Status of Shipbreaking & Prospects Best practices for sustainable ship-breaking Problems & Prospects of Shipbreaking Environmental protection during shipbreaking	- Alang (India) Alang (India) South Asia Turkey Alang (India) South Asia Chittagong Bangladesh - Alang (India) -
Quantitative	Mikelis (2007) Reddy et al. (2003) Reddy et al. (2004a) Reddy et al. (2004b) Reddy et al. (2005b) Reddy et al. (2005b) Pathak (1997) Tewari et al. (2001)	Statistical overview of ship recycling Quantitative assessment of ship-scrap waste Assessment of energy potential of solid waste Heavy metal concentration in coastal sediment Combustible waste: energy content modeling Study of contamination levels in coastal water Impact of shipbreaking on water sediments Effect of waste from ship scrapping industry on biomass production and biodiversity	- Alang (India) Alang (India) Alang (India) Alang (India) Alang (India) Alang (India)
Case Studies	Thomas (2007) Pelsy (2008)	French Aircraft carrier "Le Clemenceau" Cruise Liner "Blue Lady"	Alang (India) Alang (India)
Methodology	Carvalho et al. (2009) Huang (2010) Deshpande et al. (2012) Deshpande et al. (2013)	Method for environmental impact modelling Treatment methods for polychlorinated biphenyls (PCBs) in ship recycling facilities To estimate heavy metal exposure to workers To develop emission factors for pollutants	Portugal China Alang (India) Alang (India)
Other / Misc.	Dimakopoulos (2005) Shama (2005) Endresen et al. (2008) Sundelin (2008) Hayman et al. (2010) Mikelis (2009)	Design for Environment / Remanufacture Life Cycle Assessment of Ships Environmental impacts of increased shipping Scope to improve IMO's Convention (draft) Technologies to reduce environmental emissions from ships during its life cycle Effectiveness of IMO's recycling regulations	-

#### Table 1. Taxonomic listing of research papers and articles on shipbreaking and recycling

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