Ship recycling: A Systematic Literature Review to analyse Laws and policies as a Contributor to Sustainability

*Mansura Akter
**Dr. Md. Arifuzzaman

Abstract

The debate on ship recycling has been growing for years because of the worldwide parallel demand for ship scrapping and environmental concerns. Scholarly interest has covered the ship recycling yards' economic benefit, environmental hazards, labour rights perspectives, loopholes in laws, etc. Nevertheless, it does not provide information about whether the benefits of the shipbreaking industry outweigh the socio-ecological costs; does not compare the governance of the shipbreaking industry in the global North versus the global South; and does not show how the governance, in particular – the laws and policies – may contribute to a sustainable ship recycling. In this review paper, we critically reviewed 257 articles on the shipbreaking industry to address the questions: i) What does the literature tell us about the fundamental challenges of ship recycling industries, laws and policy frameworks about this industry, the connection of laws and policies with the specific challenge and ii) What are the possible inputs in laws and policies for this industry to be sustainable. The answers are found in putting a more critical approach to making the ship recycling laws and policies for a sustainable conversion.

Keywords: Ship recycling, Laws and policy, Governance, Literature review

Introduction

New ships are being built by shipbuilding industries and operated worldwide every year. According to the "Allianz Global Corporate & Specialty" report, in 2022, the estimated number of ships in the global fleet was 130,000, while the number was 80,000 in 1992 . So, the total of 50000 ships has increased grossly in the last 30 years. The operation of vessels may get finished for many reasons like being sunk, submerged, fire or explosion, wrecked or stranded, in a collision, machinery failure, etc . If nothing happens, ships have an average service time of 25-30 years; after that, they lose their seaworthiness and retire. Now, at least 700 vessels end their service capacity yearly and join the ship graveyard to dismantle (Galley, 2014). The most common way of managing obsolete vessels and eliminating the vast amount of shipwrecks is dismantling. This is the process of cutting the ship part by part, collecting the recyclable and reusable materials, and dismissing the rest. The

*Integrated PhD Researcher, ISCTE-IUL, Portugal.
**Assistant Professor & Chairperson, Department of Law, Green University of Bangladesh.

initial history of ship recycling is that it was initiated to eliminate shipwrecks in the countries of the Global North. Still, since the 20th century started, 90% of ship recycling yards have been shifted to the so-called Global South – mainly in India, China, Turkey, Pakistan, and Bangladesh.(Ahmed & Siddiqui, 2020).

The rapid growth in publications and the increasingly diverse topics covering ship recycling indicate the expansion of scholarly interest in the subject in recent years. The authors of different disciplines have covered the literature on the ship recycling industry from diverse disciplinary approaches. This paper aims to check the available literature and the gaps in knowledge and then conclude with the law and policy framework as a contributor to the sustainability of the industries.

Our work complements that of (Dey et al., 2021), which reviews the sustainability challenges and enablers of the ship recycling industries. The novelty of our contribution is that this is the first study to examine the role of law as a contributor to good governance in ship recycling.

2. Research Methodology

We conducted a systematic literature review (Xiao & Watson, 2019) on the governance of the shipbreaking industry to ascertain the current state of knowledge about the research focus. During the study, we followed the checklist for 'Preferred Reporting Items for Systematic and Meta-Analyses (PRISMA)'(Adeyinka-Ojo, 2021). This included searching for articles, dissertations, books in databases such as "Scopus," "Science direct," and "Elsevier," and "Manupatra" Journals searched included "Shipbreaking," "Ship recycling," "sustainable ship recycling," "ship scrap," "dismantling ships," Policy framework in the shipbreaking industries," "Legislations on Shipbreaking," and "International Conventions for Shipbreaking."

3. Study Scope and Literature Search

The scope is limited to peer-reviewed scientific articles and conference papers, with accessible full text in English that contains the term "ship breaking" and "ship recycling," "ship scrapping," and "dismantling ships" in their titles and abstracts. The selection process does not include relevant papers written in other languages, reports, books, and newspaper articles.

We have found 344 Articles, 132 Conference Papers, 48 Review documents, 22 Conference reviews, and 15 book chapters on the topic. Then we limit our review paper to peer-reviewed Articles.

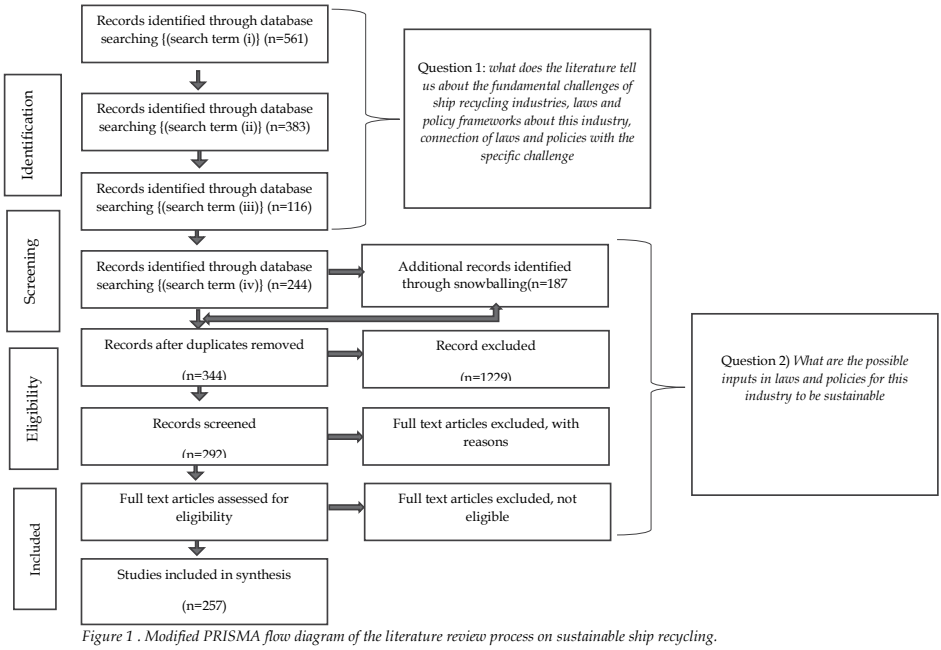

Figure 1 . Modified PRISMA flow diagram of the literature review process on sustainable ship recycling.

4. Gaps in the existing literature

We identify three gaps in the scholarship:

(a) whether the benefits of the ship breaking industry outweighs the socio-ecological costs;
(b) a comparative analysis of the governance of the ship breaking industry in the global North versus the global South; and
(c) how the governance, in particular – the laws and policies – contribute to sustainable ship recycling?

5. Thematic clustered

5.1 Environment and Ecology

We reviewed 49 papers on the ship recycling area's environment, human health, and ecology. In ship scrapping activities, several materials are discharged, which are alleged to be hazardous to the environment and human beings (M. Hossain & Islam, 2006). The environmental challenges include damaging the air, water, aquatic habitat, and land due to breaking the hazardous elements and chemicals in the recycled ships. This affects the local ecosystems and hence the industries dependent on them, such as fishing, which affects their livelihoods and food security. More than the standard amount of cadmium, copper, lead, chromium, manganese, iron, and zinc are

the common heavy metals detected in the water and sediment from the ship recycling neighbourhood. (Aktaruzzaman et al., 2014). Nevertheless, petroleum and hydrocarbon seem to be the most dangerous heavy metal (as they are mostly toxic and persistent) found in the sediment and water of the Sitakund beach of Bangladesh. (Hasan, Kabir, Selim Reza, Zaman, et al., 2013). The trace metals concentration of Cd, Cu, Zn, Fe, Mn, Cr, and Pb are more than the recommended level in the sediments of the shipbreaking area, and the negative correlation between the ship recycling activities and pollution is proved by using 'Flame Atomic Absorption Spectrophotometer' test. (Hasan, Kabir, Selim Reza, Nazim Zaman, et al., 2013) (Mohammed et al., 2003). In the Alang-Sosiya ship recycling yards in India, the concentration of heavy metal and toxic chemical range and salinity in the water and sediment are highest during the winter season because of shipbreaking activities at low tide. (Srinivasa Reddy et al., 2005). In Alang-Sosiya, the maximum non-recyclable wastes from ships are dumped along the coast so that the wave may carry the trash to the deep sea or burn it on the beach; both methods pollute the environment. (Reddy et al., 2003) There are different shipbreaking methods: docking, pier breaking, landing or slipway, and beaching. The beaching system is used for ship recycling in the total shipbreaking yards, e.g., Bangladesh and India. In the beaching system, "dry" access is possible for the workers. The scuttled ship is typically cut from the bow and deck, and these cut pieces and the lightened hull are dragged closer to the beach with winches. Commonly, hull access by dry-beaching is used as the prime method of ship scrapping. These non-facilitated beaches are receivers of debris and contaminants from a broad spectrum generated during demolition (M. S. Hossain et al., 2016). (Sunaryo & Pahalatua, 2015). The interconnection between the pollutants results in polluting groundwater from the seawater.(Hasan, Kabir, Selim Reza, Zaman, et al., 2013) The hazardous materials are almost double in the Marchant and military vessels compared to the fishing and auxiliary vessels.

There are some papers on the environmental perspective of ship recycling activities. The articles discuss the damage from the industry in the Bay of Cardiz (Alcaide et al., 2017a); analysis of the hazardous chemical concentrations in the shipbreaking industries area (M. W. Alam et al., 2018); focus on the ecological distribution conflict in Alang-Sosia India (Demaria, 2010); focus on the estimating resource consumption rates and emission factors for ship recycling yards in Alang, India (Deshpande et al., 2013a); analyse the risk assessment method of ship recycling (Garmer et al., 2015); explore the material composition of end-of-life ships using onboard documentation (K. P. Jain et al., 2016); discuss the Shipbuilding Trends in Response to Environmental Issues (Klein, 2007); analyses different methods of ship breaking and the types of pollutants they produce (Barua et al., 2018); analyses the result of covid-19 lockdown on the ship recycling yards of Alang-sosiya, India (Chanchpara et al., 2021); makes a comparison between the soil contamination from open beach ship breaking and typical industrial activities (I. M. M. Rahman et al., 2019)

5.1.1 Human health: diseases and longevity

We reviewed 11 papers discussing human health relations in ship-breaking activities. These types of Articles analyse the health challenges of the shipbreaking workers (Asante et al., 2012); focus on estimating potential maximum heavy metal exposure to ship recycling yard workers in Alang, India (Deshpande et al., 2012); Investigate the occupational noise exposure in a ship recycling yard anaemia; focus on the prevalence of anaemia burners as a lead hazard in shipbreaking (McCallum et al., 1968); Assess human health risk as a result of soil contamination in ship recycling yards in Bangladesh (I. Alam et al., 2019);

All the scholars agreed on the negative co-relations between human health and ship recycling activities. The most common hazards are oil bacteria, asbestos, heavy metals, and persistent organic pollutants (Yan et al., 2018). The workers of shipbreaking yards are directly exposed to asbestos. The scientific evidence suggests that asbestos cause lung and laryngeal cancers and malignant mesothelioma and may also cause ovarian and gastrointestinal cancers (Wu et al., 2015). In comparison between the dockworkers and the steel cutters, the second one seems to be at more risk than the former, as a higher amount of lead has been detected in their blood and urine in Taiwan. (Basha et al., 2007). A high mortality rate from different types of cancer has been seen among the workers of ship recycling yards in Taiwan. (Wu et al., 2013). The Stockholm Convention on persistent organic pollutants, 2004 has declared twelve organic pollutants: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene which are highly contaminant to human health. Among those, at least five are available in the air of the Chattogram Ship Recycling yard area. (Nøst et al., 2015). One result of working with lead exposure results in reducing haemoglobin. (Tola et al., 1976)

5.1.2 Water ecology: fishes and other living and non-living resources

There are few scholarships on the effect of ship recycling on water ecology. We reviewed three papers discussing ship recycling activities' impacts on the water ecology. There is scholarship on the recycling effect of waste oil from fishing vessels on the ocean ecology and the probable solutions to the problem (B. Lin et al., 2007). Unregulated ship recycling activities are causing a significant disturbance and release toxic material into the environment, resulting in adverse effects on marine and coastal life, including fish, mammals, birds, reptiles, plants, phytoplankton, and benthic invertebrates. (Abdullah et al., 2013). Discharging chemicals into the seawater from dismantled ships results in the disappearance of mangrove forests and vegetables in the contiguous zones and reduces the biological production of fish and other living resources in the water. (Demaria, 2010).

5.2 Economics

We reviewed 13 papers related to the economy of ship recycling.

From the viewpoint of economics, shipbreaking activities can be categorised into standard and substandard methods (Choi et al., 2016). There are four different methods of shipbreaking which makes a difference in terms of costs; viz; i) the landing method ii) along-side method iii) drydock method iv) beaching method; among them, the most expensive is the drydock method due to its time consuming and more technology-based as well as maintaining a requisite environmental standard (Choi et al., 2016). The beaching method is the cheapest because of less labour cost and substandard environmental regulation (UNEP, 2013). The New York beaches followed the drydock method, called the standard method; on the other hand, Turkey uses the landing and along-side method; Sitakund, Bangladesh, is alleged to be using the beaching method (Choi et al., 2016).

The scholars also cover the economics of ship recycling. There are writings on the methods to analyse the sustainability of shipping (Cabezas-Basurko et al., 2008); analysis of the market around the shipbreaking industry (Yin and Fan, 2018); analyses of the labour market of shipbreaking industries (Das & Shahin, 2019); discuss the funding policy in the ship breaking of South Asia (Yujuico, 2014); discuss the consumer characters of shipbreaking industries in Bangladesh (N. Gregson et al., 2010); analyse the Econometric of the ship demolition market (Knapp et al., 2008); explore the local added value in the shipbreaking (Ko & Gantner, 2016); Statisticians also have done some calculations and overview the Statistics of Ship Recycling (Mikelis, 2008);

5.2.1 Contribution to the local economy

There are some articles on the specific case countries where ships are being dismantled. We reviewed 21 Articles describing the economic contribution of ship recycling activities in Bangladesh, India, Pakistan, Turkey, and other countries. In Bangladesh, the world's highest shipbreaking country, 60% of the steel needed in different industries comes from ship scraps, and more than 1,50,000 people are occupied. (Zakaria et al., 2012). The country has no direct source for iron ore and earns a high GDP percentage from the ship-breaking business. (Sujauddin et al., 2017). The shipbreaking activities in Pakistan can also be a good example for economic benefit; where the source of obsolete vessel market is mainly smuggling from Iran and Afghanistan; even then, the Government of Pakistan seems to be flexible about this business because of its contribution to steel industries, employment opportunity and contribution to the local economy. (Ahmed & Siddiqui, 2020)

5.2.2 Cost-effectiveness

Some authors discuss the recyclability and cost-effectiveness of ship

recycling. We reviewed 13 Articles that examine the cost-effectiveness of ship recycling activities. Some read about the reproduction of raw materials like rechargeable lithium-ion batteries from obsolete vessels (Lee et al., 2018); estimate the comparative rate of resource consumption and emission factors in the Alang-Sosiya ship recycling yard, India (Deshpande et al., 2013b);

From the economic perspective of dismantling an obsolete vessel in a low-cost method and country and recycling its reusable parts, ship recycling seems more cost-effective in the Global South than in the Global North. (Zhou et al., 2021). The value of the scrap materials can be 50% higher in Asia than in Europe. (Buxton, 1991) Among the Global South countries, it is described in some papers that it is most cost-effective in Bangladesh. While analysing the effect of the currency exchange rate on ship scrap values, it is found that even when the local currency rate falls, the Bangladeshi trade-off of ship scrap didn't get affected. At the same time, India, Pakistan, and China reacted negatively to the purchase of scrapped vessels. The authors have described Bangladesh's dependence on specific businesses. (Karlis et al., 2022).

The vicious cycle of offering a lower price for the higher cost in green recycling yards makes the green yards economically less attractive and less cost-effective. (K. P. Jain et al., 2017)

There are scholarly works covering both the economics and environmental relevance of ship recycling. There are analyses of the economic and environmental challenges (Choi et al., 2016); analyses of the survival challenges of the ship demolition markets (Yin & Fan, 2018); discuss the Trace metals pollution in seawater and groundwater in the ship breaking area of Sitakund Upazilla, Chittagong, Bangladesh (Hasan, Kabir, Selim Reza, Zaman, et al., 2013)

5.3 Social and Political Relevance

5.3.1 Social values

In this part, we have found three relevant papers. The authors focus on the social and religious value of recycled materials. The souvenir salvage from an old military vessel is of religious and archeologic heritage. (Nicky Gregson et al., 2011); The collection of pottery from the excavation of the Dor D shipwreck of Israel proved the continuity of trade in a post-plague economic trend with neighbouring countries. (Kingsley, 2003); focuses on the recycling arts, where recycled parts of ships can be converted into art pieces (Laviolette, 2006);

5.3.2 Rights of the labour people

There are few papers on the labour rights issues in ship recycling. We reviewed seven articles about the rights of labour people in ship recycling yards. These

types of articles evaluated the status of current occupational training in the ship recycling industry in Bangladesh and other South Asian countries (Gunbeyaz et al., 2019); The labour exploitation part can be assessed through two different approaches; i) the health challenges of the workers due to the hazardous nature of working at ship recycling yards, and ii) the different rights of the worker's worker's hazards can be summed into three types: i) the hard manual labour involving heavy lifting; long-term exposure to fire and sun caused by working operations and lack of personal protective equipment (PPE); and ii) exposure to hazardous substances/toxins (Andersen, 2001). Out of the hazardous nature of work, the low rate, remuneration, and other job facilities, namely, working hours, weekly holiday, rest and recreation, bills for overtime, and medical benefits, are all inadequate and minimal in the shipbreaking yards. (Sahu, 2014) Working in the ship breaking yards is dangerous because it comprises many human health risks. Sometimes gas explosions, falling steel parts, and toxic chemicals can occur fatal accidents. The most exposed occupation are welders, plumbers, painters, repairers, and sheet metal workers. (Tola et al., 1976)

5.3.3 Local People

We reviewed 13 papers related to the local people in the ship-breaking area.

Shipbreaking activities directly impact the lifestyle of the people working in the shipbreaking yards, the fishing communities, the farmers, and other villagers. (Demaria, 2010). There is a reason for dissatisfaction over the lack of availability of necessities of life among the working people in the ship-breaking yards. (Memon & Zarar, 2016). Ship recycling activities are proven responsible for persistent organic pollutants like polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in the ambient air of Turkey, which seems dangerous to human health due to toxicity. (Aydin et al., 2014).

Some papers are written in the context of shipbreaking in Bangladesh. The literature analyses the Bangladeshi Laws on Shipbreaking (M. S. Hossain et al., 2016); analyses the policy compliance challenges in the shipbreaking yards of Bangladesh (Chowdhury, 2017); discusses the Overview of the Ship Recycling Industry of Bangladesh (K. A. Hossain, 2015); discuss Impact of ship-Breaking activities on the coastal environment of Bangladesh and a management system for its sustainability (M. S. Hossain et al., 2016); discuss the problems of ship recycling industries of Bangladesh (Zakaria et al., 2012); discuss Ship Recycling and Its Environmental Impact in Bangladesh (Jobaid et al., 2014); Assess the Energy-Based CO2 Emission and Workers' Health Risks at the Shipbreaking Industries in Bangladesh(Mitra et al., 2020);

Scholars also have concentrated on the local life of the ship recycling areas. There are discussions on the impacts of shipbreaking industries on the life of local people of Bangladesh (Kutub et al., 2017);

5.3.4. The Geopolitics of ship recycling

We reviewed nine papers discussing the geopolitics in ship recycling activities.

The eighteenth-century history speaks of shipbreaking as a concept of the Global North rather than the global South (Das & Shahin, 2019). Such business was initially detected in some of the highly industrialised countries of Europe, the United States, and Japan (Pastron & Delgado, 1991). The California Gold Rush was an event in mid-1850, when hundreds of ships from around the world lay at anchor in San Francisco Bay, to the east of the rapidly growing metropolis (Pastron & Delgado, 1991). History says, later, in the 1970s, the ship recycling industry moved to Taiwan, China, and South Korea. Then, with the flow of time, since the 1980s, the industry has gradually moved to the countries of South Asia, including Bangladesh, India, and Pakistan (Kagkarakis et al., 2016). Waste: now the day is treated as a political material (Nicky Gregson et al., 2013); Before the Basel ban (the restriction of transboundary movement of hazardous materials imposed by the Basel Convention, 1989), Europe allegedly exported approximately 120000 tons of dangerous waste; namely asbestos, mercury, ash, heavy metal, clinical debris, PCB, waste pesticides to developing countries namely India an Africa, what came to the point of discussion when, in 1988, the Organization for African Unity (OAU) has declared the dumping of nuclear waste to Africa as a crime. (Sonak et al., 2008). The ship recycling business is compared to neo-capitalism, where the poor are involved as producers and argued that the concept of doing something good in such a hazardous industry is "a great illusion!"(Cairns, 2014). In capitalism-related theoretical analysis, where nature is considered as a social element, the flow of scrap vessels from consumer to breaker country; or from reach to a developing country proves not only the market imperatives of supply and demand but also the political struggles over environmental and social justice locally, nationally and globally. (Hillier, 2009). The presence of suppression has also been assumed in among stakeholders from different parts of the same country. In Sitakunda, Chattogram (Bangladesh), The most hazardous and low-paid jobs like loading and cable pulling are reserved for the migrant workers from North Bengal. In contrast, the less dangerous and better-paid ship-based jobs are reserved for the local workers from Chattogram. (Courtice et al., 2011).

It is assumed that the geographic sensitivity of countries of the global North like Europe, America, and Japan led to the movement of Shipbreaking activities from the global north to the global south. Countries in Asia like Japan, which are developed to considerable extents but are geographically vulnerable because of their unstable weather threatened by earthquakes, volcanos, and tsunamis. (Robertson et al., 2013). Comparatively, the countries called the global south; seem more confident or, to some extent, less careful or have fewer options for establishing such hazardous industries (Remigios, 2010).

5.4 Sustainability

We reviewed 13 papers that discussed sustainable ship recycling.

There are some works of literature on the sustainability prospect of ship recycling. The papers mainly discuss The Safe and Environmentally Sound Recycling of Ships and Its Application in China (Du, 2012); focus on Challenges and solutions for ship recycling in China(Du et al., 2017); discuss the probable development plan for the shipbreaking industry (Hiremath et al., 2016); discuss the Concept of Green shipping practices in the shipping industry (Lai et al., 2011); analyse Modelling trade-off in ship breaking industry considering sustainability aspects (Kusumaningdyah et al., 2013); Analyse comparatively in between the existing practice and the possible sustainable method of recycling. (Shimizu et al., 2012); discusses the factors that may influence green ship recycling. (Zhou et al., 2021); analyse the components and challenges of sustainability already addressed in the existing literature on ship recycling (Dey et al., 2021); focus on the method of clustering the recycling yards in the Alang-Sosia, India, with a view to vessel type (Hiremath et al., 2014)

"Green ship recycling" and "sustainable ship recycling" are two parallelly used synonymous terminology. Both indicate a sense of non-violence to nature. (Nicky Gregson, 2011). The main elements of green ship recycling are described in the Chapter-3, Requirements for ship recycling facilities, of the Hongkong Convention, 2009" and Article 13:Requirements necessary for ship recycling facilities to be included in the European List, of the European Ship Recycling Regulation, 2013''(Kanu Priya Jain et al., 2018). The steps for green recycling include changing the distribution strategies, reducing waste, and managing treatment to recycle, reuse, and reduce the raw material sources. (Schøyen et al., 2017)(Sunaryo & Pahalatua, 2015)

5.5 Laws and Governance of Ship Recycling

We reviewed 16 papers on ship recycling activities' laws and policy frameworks.

The Basel Convention 2011 and the Hongkong Convention, 2009; and the European Ship Recycling regulation, 2013 are the three key instruments to deal with ship recycling legislations internationally, are allegedly emphasised strongly procedures and authorisations instead of substantial obligations. (Argüello Moncayo, 2016). The "before-after Hongkong convention" comparison between the Chinese Law on ship recycling reflects loopholes in Chinese laws and recommends inputting environmental concerns into the legislation. (Zhao & Chang, 2014). The role of the European ship recycling Regulation seems limited within the ship recycling facilities in Europe and remained untouched for the Global South, where 70% of the global ship recycling activities are done. (L. Lin et al., 2022)

Some scholars wrote on laws relating to ship recycling. Those papers assess European policies (Alcaide et al., 2017b); the potential and challenges of recycling in

the industry (Alter, 1997); analyses of the Basel Convention on the Transboundary Movement of Hazardous Wastes (Bhattacharjee, 2009); Analysis of the Hong Kong Convention (Chang et al., 2010); assessed the Basel Convention's role on the control of transboundary movements of hazardous waste and their disposal (Westing, 1998); discuss ways of Safe and Sound Scrapping under the Hong Kong Convention on Ship Recycling (Matz-Lück, 2010); analyse the European Regulation on ship recycling (Mikelis, 2013); discuss the elements of the Basel Convention and its application to toxic ships (Moen, 2008); relates the potential application of the polluter pays principle in this sector (Ambec & Ehlers, 2016)

6. Conclusion

This paper presented a systematic review of ship recycling industries. By focussing on different journals, this work explored the paradigmatic beliefs, methodological approaches, and methods underpinning the ship recycling industries. Overall, this systematic review indicates that the absolute clustering of the articles for the specific subject matter is not possible because of the critical epistemological position of the authors. After analysing the papers, we conclude that the available literature has discussed many aspects of ship recycling. However, a mentionable part has remained untouched and needs further research. In this paper, we first have found the challenges of ship recycling, then checked the laws and policy connection with the specific challenge, and then analysed the possible input in the rules and policy framework for sustainable ship recycling. Irrespective of the environmental challenges, such an industry's economic and social relevance cannot be ignored entirely. To summarise the current demand for ship recycling activities, the quotation from Cairns seems relevant; Ship recycling can be compared to a combination of ugly and beautiful. (Cairns, 2007) Regarding the environmental and health-related concerns, almost all the authors agreed on the hazardous nature of ship recycling activities. The authors are also on the same point, recognising that ship recycling activities are of fundamental economic purpose. The scholarship becomes split down into different opinions while the question of social-political-geopolitical and sustainability-related questions arise. This is common that in the ship-breaking legislations, the reflection of a balanced critical approach from an environmental-economic-social-political viewpoint is still missing. So, we conclude that the inclusions of ideas mentioned above in the international-regional and local laws and the proper implementation with the cooperation of international entities and instruments can contribute to sustainable ship recycling.

Annex 1: Tables and Charts

Distribution of papers: Publication type

The following table is the result of Scopus searching on "Ship Recycling."

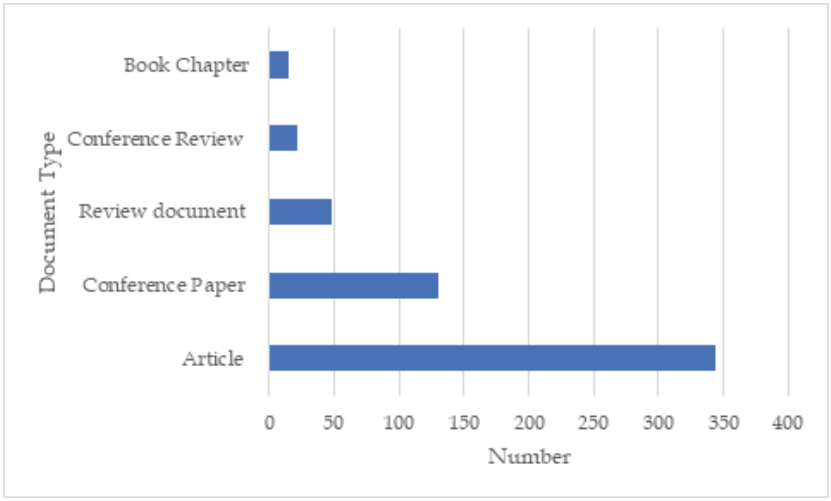

Figure 2: Numbers of Publication type

Shipbreaking literature published by year (1973-2022)

We have found 19 papers published from 1973-1989, 41 papers during 1990-1999, 145 documents from 2000 to 2009, and 342 from 2010 to 2021.

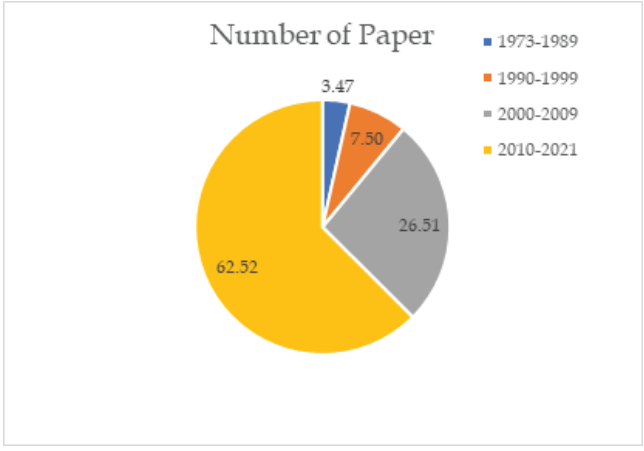

Figure 3: Number of publications by year

Shipbreaking literature by country

The scholarship on the shipbreaking industry published in different countries are below:

Table 1: Number of Publications in Different countries

Name of the Country	Number of Literature	Name of the Country	Number of Literature	Name of the Country	Number of Literature
United States	88	Canada	13	Denmark	7
China	69	Italy	13	Portugal	7
United Kingdom	52	Netherlands	13	Singapore	7
Japan	36	Norway	11	Spain	7
India	23	Belgium	9	Indonesia	6
Turkey	23	Poland	9	Taiwan	6
Germany	19	Malaysia	8	Romania	4
South Korea	19	Australia	7	Switzerland	4
France	16	Brazil	7	Chile	3
Bangladesh	13	Croatia	7	Saudi Arabia	3
Austria	2	Thailand	2	Jordan	1
Hongkong	2	United Arab	2	Latvia	1
Iran	2	Cape Verde	1	Lithuania	1
Nigeria	2	Czech Republic	1	Philippines	1
Pakistan	2	Egypt	1	Slovenia	1
Qatar	2	Eritrea	1	Togo	1
South Africa	2	Ireland	1		

Shipbreaking literature by discipline

We have found 491 papers from Engineering, 213 from Environmental Science, 74 from Energy discipline, 74 from Social Science, and 72 from material science.

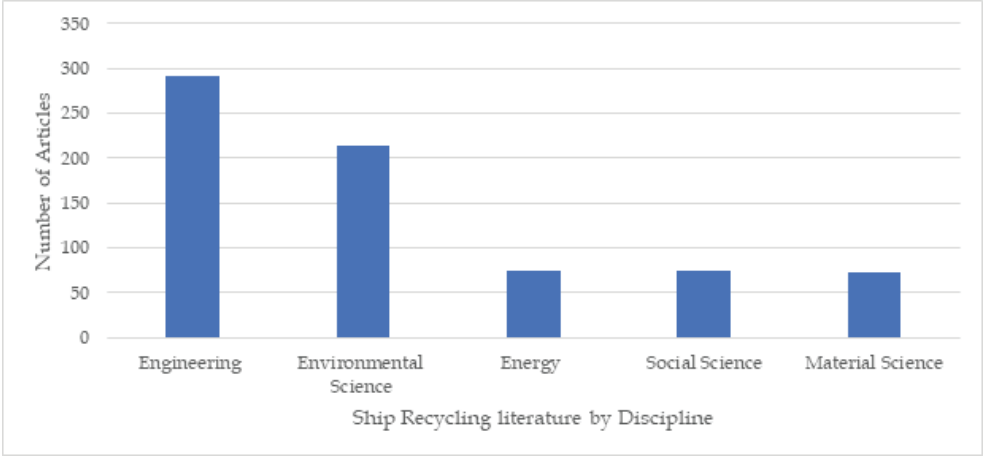

Figure 3: Ship Recycling Papers by Discipline

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