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Blue Economy and the Impact of Industrialisation on Sustainable Livelihoods: A Case Study of Fisheries in the North Coastal Region of Java

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Abstract

This research explores the impacts of the blue economy and industrialisation on sustainable livelihoods in the coastal areas of the North Coast of Java, with a particular focus on the fisheries sector.The main objective of this research is to analyse how changes in blue economy practices, which include sustainable marine resource management approaches, interact with industrialisation processes and their impact on the survival of local fishing communities.The research method used was qualitative with a case study approach, where data was collected through in-depth interviews with fishermen, government officials, and relevant stakeholders, as well as direct observation in the field. Data analysis was conducted using thematic analysis techniques to identify patterns and significant relationships between the factors involved.The results of this study show that industrialisation in the coastal areas of Java's North Coast has vital and complex impacts on the sustainable livelihoods of local fishing communities. On the one hand, industrialisation provides new economic opportunities, such as jobs in the fishing and manufacturing sectors, which can increase community income. However, on the other hand, negative impacts on the aquatic environment due to industrial activities and overexploitation of natural resources threaten the sustainability of the marine ecosystem, which is the main source of livelihood for fishermen.The managerial implications of these findings emphasise the need to integrate blue economy policies with the maturity of sustainable industrial development planning. Policy development that accommodates the needs of local ecosystems and fishing communities, with a pattern of regulating marine protected zones and supporting the shift to environmentally friendly fisheries practices, is key to ensuring the sustainability of fishers' livelihoods and healthy coastal ecosystems. This research provides important insights for policy makers and practitioners involved in marine fisheries resource management and industry development in coastal areas.

Keywords: *Blue Economy, Industrialisation, Livelihoods, Sustainability, Fisheries.*

Introduction

On 30th January 2020, the World Health Organization (WHO) announced a state of international The blue economy is a concept that promotes a balance between the utilisation of marine resources and the preservation of maritime ecosystems to promote sustainable development. Fisheries as the main sector of the blue economy has an important role in providing livelihoods for coastal communities, especially in Indonesia, which is the largest archipelago in the world (Ayilu, Fabinyi, Barclay & Bawa, 2023). The coastal area of Java's North Coast (Pantura) is one of the centres of fisheries activity in Indonesia, with thousands of fishermen who depend on marine products to meet their daily needs. The fisheries sector in this region contributes significantly to food security, local economic growth and poverty alleviation (Marbun, 2016; Haimbala, 2019).

However, in recent decades, rapid industrialisation along the Pantura has begun to affect marine ecosystems and fisheries resources. Many studies have revealed that the negative impacts of industrialisation such as water pollution, marine habitat degradation and increased commercial activities have threatened the sustainability of fishers' livelihoods (Choudhary et al, 2021). This raises concerns that if not properly managed, the long-term impacts of industrialisation could exacerbate the environmental crisis and threaten the social and economic lives of coastal communities (Fang et al, 2021).

Blue economy is a sustainable development concept that emphasises the importance of marine and coastal ecosystems in creating economic growth without damaging the environment (Midlen, 2021). The coastal area of the North Coast of Java is one of the strategic areas in Indonesia that has great potential in the fisheries sector. Various economic activities, ranging from fishing, aquaculture, to seafood processing, are

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the main sources of livelihood for local communities. Data shows that the contribution of the fisheries sector to the regional economy reaches 30% of the total GRDP (Gross Regional Domestic Product) in the coastal area, with more than 200,000 people depending on this sector for their survival (BPS, 2023).

Table 1. Contribution Data of the Fisheries Sector in the North Coast of Java

Year	Contribution to GRDP (%)	Number of Fishermen	Fisheries Production (Tonnes)
2018	28	190,000	450,000
2019	29	195,000	470,000
2020	30	200,000	490,000
2021	30.5	205,000	500,000
2022	30.7	210,000	510,000

Source: Central Bureau of Statistics (2023)

However, along with industrial growth in coastal areas, challenges to the sustainability of coastal communities' livelihoods are increasing (Martínez-Vázquez, Milán-García & de Pablo Valenciano, 2021). Industrialisation, both in the form of infrastructure development and processing industry activities, has put significant pressure on coastal ecosystems (Siswanto & Rosdaniah, 2023). Marine pollution, reduced fish habitat, and changes in local climate patterns are some of the impacts that threaten the sustainability of traditional fisheries. The impact of industrialisation is exacerbated by the lack of strict regulations in managing industrial development in coastal areas. As a result, many traditional fishers have experienced a decline in catches, while access to marine resources is increasingly limited. For example, fish production in some coastal villages has decreased by an average of 5% per year since 2018 (Fisheries Service, 2022).

In the midst of economic growth and industrialisation along Java's North Coast, the challenge of blue economy sustainability has never been more pressing. Industrialisation, initially seen as a solution to improve people's lives, has brought major complications for marine ecosystems and traditional livelihoods (Bennett et al, 2020). Industrial pollution, overexploitation and loss of coastal areas that provide livelihoods for small-scale fishers are some of the problems that have emerged (Raimi, Kah & Tariq, 2022). The impact of industrialisation on the fisheries sector in the Coastal Zone has revealed a conflict of interest between economic growth and environmental sustainability (Coulthard et al, 2011). Fishermen who once depended on the sea now face declining catches, the destruction of mangrove ecosystems that serve as fish spawning grounds, and declining seawater quality due to industrial waste. In addition, small-scale fishers often do not have access to technology or capital to switch to more sustainable fishing methods, further marginalising them from the impacts of industrialisation (Siswanto & Rosdaniah, 2023; Midlen, 2021).

While there have been many studies on the impacts of industrialisation on coastal ecosystems and the fisheries sector, few studies have specifically examined the impacts of industrialisation on the North Coast of Java using a blue economy approach. In particular, not many studies have explored how industrialisation affects the sustainability of small-scale fishers' livelihoods in this region. Previous studies have focused more on industrial pollution or exploitation of marine resources, but have not integrated the concept of blue economy as a framework to analyse the linkages between industrialisation and sustainable livelihoods (Pérez-Ramírez et al, 2016). More in-depth and specific research in the Pantura, using a blue economy approach, could provide more comprehensive insights into solutions to balance industrialisation and sustainability of the fisheries sector (Martínez-Vázquez, Milán-García & de Pablo Valenciano, 2021).

The concept of blue economy has gained significant attention in recent decades, particularly in relation to environmental sustainability and improving the economic well-being of coastal communities (Silver et al., 2015; World Bank, 2017). However, research focusing on the influence of industrialisation on sustainable livelihoods in coastal areas, particularly in the context of developing countries such as Indonesia, is limited. Most of the existing literature highlights the role of the blue economy in managing marine resources and supporting environmental sustainability (Allison et al., 2012; Cisneros-Montemayor et al., 2019). However,

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there are few studies that directly link industrialisation in coastal areas with sustainable livelihood implications for local communities (Patterson & Brown, 2018).

Furthermore, many studies focus on the economic benefits of industrialisation and globalisation in the fisheries and marine sectors without considering the long-term negative impacts on coastal communities, such as loss of access to natural resources, environmental degradation and economic inequality (Bennett et al., 2020; Coulthard et al., 2011). As a result, there is still a gap in understanding how rapid industrialisation in coastal areas can threaten sustainable livelihoods and ignore blue economy principles that should support a balance between economic development and socio-ecological sustainability (Pérez-Ramírez et al., 2016).

This research seeks to fill this gap by examining in depth the influence of industrialisation on the livelihoods of coastal communities in the North Coast of Java, which is one of the most highly industrialised regions. The study aims to explore whether industrialisation supports or hinders the achievement of economic, social and environmental sustainability in the region, and provide more holistic and inclusive policy recommendations in support of a sustainable blue economy (Nash et al., 2016; Bavinck et al., 2018).

A major concern in this context is how coastal communities, particularly small-scale fishers, can sustain their livelihoods amidst the pressures of industrialisation. Declining catches, pollution and degradation of marine ecosystems not only threaten local economic viability but also disrupt the social and cultural balance that has been established over the years. Coastal communities dependent on the fisheries sector face serious threats to their sustainability, with increasingly limited access to healthy and productive marine resources (Hadjimichael, 2018). In addition, there are concerns that development policies that favour industrialisation without considering environmental impacts may exacerbate these conditions. Without appropriate interventions, the gap between those who are able to adapt to change and those who are not will widen (Wright, 2015).

This research will focus on identifying strategies that can be implemented within a blue economy framework to create sustainable livelihoods for Pantura coastal communities amidst the pressures of industrialisation. Potential solutions that will be analysed include the application of environmentally friendly technologies in fisheries, stricter management of industrial waste, and strengthening regulations that support the sustainability of marine ecosystems. Blue economy approaches will also be explored through collaboration between the government, private sector and local communities in an effort to build an economic model that prioritises not only growth, but also social and ecological sustainability. In addition, there is a need for empowerment programmes for small-scale fishers to improve their skills and access to sustainable technologies, so that they can be more adaptive to the changes brought about by industrialisation.

This research will contribute to a deeper understanding of the relationship between industrialisation and livelihood sustainability in the Pantura fisheries sector. Using a blue economy framework, this study not only highlights the impacts of industrialisation, but also offers solutions that focus on long-term sustainability. Another important contribution is to provide policy recommendations that can be implemented by local and national governments to ensure that industrialisation in coastal areas can go hand in hand with the preservation of marine resources and the improvement of fishers' welfare. This study is also expected to be a reference for future research that wants to further explore the integration of blue economy in sustainable development in Indonesia's coastal areas.

Literature Review

Sustainable Development

Sustainable development theory focuses on the balance between economic, social, and environmental aspects, aiming to achieve long-term prosperity without damaging the ability of future generations to meet their own needs. This principle was first introduced in the Brundtland Report (1987) by the World Commission on Environment and Development. Sustainable development demands that economic activities must not only be orientated towards short-term profits, but must also maintain ecosystem and social balance. In fisheries and aquaculture, this means maintaining fish populations and the marine

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environment to support food security and the economies of the communities that depend on the sector. Sustainable development is particularly important in the Indonesian context, where coastal and marine ecosystems are vital natural resources for economic and social well-being (Bjørndal & Munro, 2012).

In the context of fisheries and aquaculture, this theory is particularly relevant given the challenges faced by the sector, such as overfishing, marine ecosystem degradation and climate change. Sustainable development emphasises that food production from the ocean must be done in a way that maintains the sustainability of marine resources. The World Bank (2013) states that fisheries and aquaculture play an important role in supporting sustainable development, especially in developing countries, including Indonesia, where coastal communities rely heavily on marine resources for livelihoods and food security. The contribution of sustainable fisheries to poverty alleviation can be seen in how the sector provides employment, reduces dependence on food imports, and provides access to affordable sources of protein (Chibite, Vieira & Morgado, 2021).

Furthermore, sustainable development in the sector includes good fisheries management, improved aquaculture technology, and empowerment of coastal communities to ensure that the economic benefits generated from the sector can be enjoyed by all (Mohanty, 2021). Sustainably managed aquaculture, for example, can increase yields without harming the environment and at the same time create economic opportunities for communities. FAO (2018) highlights the importance of sustainable development approaches in fisheries and aquaculture to improve global food security and reduce poverty in coastal countries. A combination of economic, ecological and social approaches is necessary for the sector to make a real long-term contribution to human development.

Poverty Alleviation

Poverty alleviation theory generally refers to a set of approaches designed to reduce poverty through increased access to economic opportunities and natural resources. This approach focuses on empowering the poor to improve their welfare independently (Allison, 2011). One of the main strategies is to encourage community involvement in productive economic activities, such as agriculture, fisheries and small industries, that can provide sustainable income. In the context of fisheries and aquaculture, this theory sees the marine sector as an important resource that can be used to empower coastal communities through improved access to markets, technology and economic infrastructure. This approach is in line with Sen's (1999) view in capability theory, which emphasises the importance of expanding individual capabilities to achieve welfare through the development of the economic potential that exists around them.

Fisheries and aquaculture play a strategic role in poverty alleviation in many developing countries, including Indonesia. With a long coastline and rich marine resources, this sector has great potential to create economic opportunities for coastal communities. The fisheries sector in Indonesia not only provides an important source of food but also creates employment for millions of people, especially in rural areas. According to FAO (2018), fisheries and aquaculture in Indonesia contribute to poverty alleviation through direct and indirect job creation in related sectors such as fishing, processing, and distribution. Coastal communities, which often suffer from multidimensional poverty, can utilise these marine resources as their main source of income, while improving their quality of life with better access to education, healthcare, and housing (Salayo, Castel & Montinola, 2022).

While fisheries and aquaculture have great potential in reducing poverty, there are various challenges that need to be overcome to optimise the benefits of this sector. One of the main challenges is the sustainability of marine ecosystems that are threatened by overfishing, pollution, and climate change. Degradation of the marine environment can have a direct impact on the productivity of the fisheries sector and ultimately hamper efforts to alleviate poverty in coastal areas. Therefore, policies that support the sustainable management of marine resources and protect coastal ecosystems are needed so that their economic benefits can continue to be enjoyed by future generations (Béné et al., 2016). In addition, it is important to increase the capacity of coastal communities through training, access to technology and infrastructure improvements to maximise the potential of the fisheries sector to create more inclusive and sustainable economic opportunities.

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Food Security

Food security emphasises the ability of a society to sustainably meet its food needs. Food security includes the dimensions of food availability, access, utilisation and stability (Einarsson & Óladóttir, 2020). This means that communities with food security can access quantitatively sufficient, quality-safe and nutritious food in the long term, without being affected by external shocks such as climate change, economic crisis or social conflict. According to FAO (2006), food security is considered achieved when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet the needs of a healthy and active diet.

Fisheries and aquaculture play an important role in realising food security, especially in developing countries. Sources of animal protein from the fisheries and aquaculture sector can be obtained at affordable prices, making it the main choice for many rural and coastal communities with limited economic resources (Akegbejo-Samsons, 2022). Fish contains essential fatty acids, vitamins and minerals that are difficult to obtain from other food sources, making it an important component of a healthy diet. According to Béné et al. (2016), global fisheries and aquaculture, including in Indonesia, significantly contribute to the provision of protein and nutrients to the wider population, especially in areas with limited access to other animal products.

In the Indonesian context, fisheries and aquaculture play a vital role in creating sustainable food security. Indonesia, as the world's largest archipelago, has enormous marine potential to support national food needs. Fish is one of the most accessible sources of animal protein for the wider community, especially in coastal areas (Bjørndal, Dey & Tusvik, 2024). Data shows that more than 50% of animal protein consumption in Indonesia comes from fish and other marine products (KKP, 2020). In many rural areas, fisheries and aquaculture are the only affordable main source of protein, contributing greatly to fulfilling the nutritional needs of the people there. Strengthening this sector is therefore crucial to achieving food security goals in Indonesia, especially in the face of global challenges such as climate change and population growth (Loring et al, 2019).

Marine Economic (Blue Economy)

The blue economy concept emphasises the importance of sustainable management of marine resources to ensure long-term human well-being. In contrast to conventional economic models that often exploit resources without considering environmental impacts, the blue economy offers a holistic approach that considers the balance between economic, social and environmental needs (Brugère et al, 2019). The concept encompasses various marine sectors such as fisheries, marine tourism, ocean energy and aquaculture. The aim is to maximise economic benefits from marine resources while minimising negative impacts on the ecosystem. According to the World Bank (2017), the blue economy also emphasises the importance of social inclusion, so that local people, especially coastal communities, can directly experience the economic benefits of sustainable marine activities.

In the context of fisheries and aquaculture, the blue economy puts forward a new approach to ensure the sustainability of marine ecosystems while improving the economic welfare of coastal communities (Evans et al, 2023). Sustainable fisheries and eco-friendly aquaculture contribute to the preservation of marine ecosystems by reducing over-exploitation practices that can damage marine habitats. Well-managed fisheries also support food security and provide a stable source of protein for communities. Sustainable aquaculture, for example, not only increases fish production, but also involves environmentally friendly practices such as efficient feed use and better waste management. A study by Patil et al. (2018) showed that the application of the blue economy in fisheries and aquaculture can increase productivity economically, while maintaining the ecological balance of the ocean.

In Indonesia, the blue economy theory is particularly relevant given the country's vast marine potential. The Indonesian government has committed to making the marine sector one of the main pillars in national economic development. One important initiative in this regard is the development of marine policies that support the sustainability of marine ecosystems, while improving the lives of coastal communities. For

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example, government programmes focusing on empowering fishers and developing a sustainable fishing industry have been part of the strategy to achieve this goal. Patil et al. (2018) also emphasised that the blue economy is not only about environmental sustainability, but also about ensuring inclusive and equitable economic growth for all stakeholders, including local ocean-dependent communities.

Research Methods

This research uses qualitative methods to explore the influence of industrialisation on sustainable livelihoods in the fisheries sector in the coastal areas of the North Coast of Java. The qualitative method was chosen because it allows researchers to dig deeper into the experiences, perceptions, and socio-economic dynamics that occur among coastal communities. This approach aims to capture the complexity of interactions between actors in the fishing industry, including fishers, entrepreneurs and local government, as well as how the industrialisation process affects working patterns, the local economy and community welfare. Through in-depth interviews, participatory observation and case studies, the research will build a rich narrative of the real and potential impacts of industrialisation on the sustainability of the blue economy in the region (Creswell & Poth, 2016).

In this study, the selection of informants is purposive, where fishermen, boat owners, fisheries entrepreneurs and government stakeholders are selected as the main subjects. Data obtained from interactions with these subjects will be analysed using a thematic analysis approach, which aims to identify key patterns related to socio-economic changes due to industrialisation. By triangulating data from interviews, observations and relevant documents, this research seeks to provide an in-depth understanding of the challenges and opportunities faced by coastal communities in the face of industrial change, and the implications for the sustainability of their livelihoods in the future (Creswell & Poth, 2016).

The qualitative research method with content analysis is particularly relevant in evaluating the contribution of fisheries and aquaculture to poverty alleviation and food security in Indonesia as this approach allows researchers to deeply understand the social, economic and environmental issues related to the sector. Through content analysis, the research was able to extract rich information from various sources such as policies, reports, scientific articles, as well as interviews with stakeholders. This systematic evaluation aims to identify patterns, trends, as well as successes and challenges faced in the implementation of fisheries and aquaculture policies and programmes in order to address poverty and improve food security. The use of content analysis also helps in developing new insights related to the dynamics of the relationship between the fisheries/aquaculture sector and the communities that depend on these resources, so as to provide more targeted recommendations for policymakers.

Results

Research Results related to Blue Economy

In-depth interviews with fishermen and fisheries industry players in the coastal areas of Java's North Coast, it was clear that the implementation of Blue Economy principles has had a significant impact on their livelihoods. The fishers revealed that despite efforts to improve sustainable fisheries practices, they still face major challenges related to declining catches and pressure from industrial activities. Most respondents reported that while they have adopted more environmentally friendly fishing methods, such as the use of fishing gear that does not damage habitats, they still experience a decline in income due to reduced fish stocks. In addition, they identified an urgent need for training and access to technologies that can improve the efficiency and sustainability of fishing businesses. On the other hand, industry players also highlighted the economic potential of the ecosystem-based tourism sector, which could provide alternative income and reduce dependence on fish catches. These interviews show that while Blue Economy principles have the potential to support sustainable livelihoods, the challenges of implementation require greater attention and support from various parties.

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Data from the Blue Economy Research on the North Coast of Java.

Research Aspects	Outcome Data	Description
Number of Respondents	50	The total respondents consisted of fishermen and industry players.
Average Catch per Vessel (kg/year)	1,200	A 15% decrease compared to five years ago.
Percentage of Environmentally Friendly Fishing Gear Use	65%	Percentage of fishermen using environmentally friendly fishing gear.
Average Income of Fishermen (IDR/year)	15,000,000	A 10% decrease compared to the previous year.
Number of Training And Support Programmes	10	Number of training and support programmes available.
Percentage of Respondents Who Adopted New Technology	40%	Percentage of respondents who have adopted new technologies.
Satisfaction with the Blue Economy Programme	55%	Percentage of respondents who are satisfied with the programme.
Number of Ecosystem-based Tourism Projects	5	Number of projects identified as revenue alternatives.

This table illustrates the research data that provides an overview of the condition of fisheries and the impact of Blue Economy implementation in the coastal areas of the North Coast of Java.

This table presents data obtained from in-depth research on the fisheries sector in the coastal areas of the North Coast of Java. The data covers various aspects related to fisheries, such as the amount of fish caught, the use of environmentally friendly fishing gear, fishers' income, and various initiatives related to Blue Economy. Blue Economy is a concept that integrates environmental sustainability with economic growth, focusing on the responsible and sustainable utilisation of marine resources. Through this table, readers can see the current state of the fisheries sector and how Blue Economy principles are implemented in the local context.

This data shows that while there are initiatives to support sustainable livelihoods, there are real challenges that need to be overcome to achieve long-term success in the implementation of Blue Economy principles.

The data results show that despite the implementation of various initiatives to support sustainable livelihoods, such as the use of environmentally friendly fishing gear and the development of ecosystem-based tourism projects, there are still significant challenges to be faced. For example, despite the high percentage of eco-friendly fishing gear use, fish catches continue to decline, indicating continued pressure on fish stocks. In addition, despite training and support programmes, fishers' incomes have not shown a significant increase and remain in decline. This indicates that existing initiatives have not been fully effective in addressing the underlying issues and achieving the long- term goals of the Blue Economy. To achieve success in implementing Blue Economy principles, there needs to be a more holistic and strategic approach that includes further improvements in resource management, greater support for fishers, and the development of innovative solutions to address existing challenges.

The results of this study show that industrialisation in the coastal areas of Java's North Coast has a complex impact on the sustainable livelihoods of local fishing communities. On the one hand, industrialisation provides new economic opportunities, such as jobs in the fishing industry and manufacturing sectors, which can increase community income. However, on the other hand, negative impacts on the aquatic environment due to industrial impacts and overexploitation of natural resources can threaten the sustainability of marine ecosystems that are the main source of livelihood for fishermen.

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The research also found that traditional fishers have difficulty adapting to the changes brought about by industrialisation. Declining fish catches due to environmental degradation and competition with more modern fishing industry sectors are the main challenges. Fishermen who lack access to technology and capital experience higher vulnerability to these changes. Furthermore, the results indicate the need for holistic policy interventions to balance industrial development and marine ecosystem conservation. Support for fishers through training programmes, access to environmentally friendly technologies, and protection of sustainable fishing grounds are key to maintaining the socio- economic well-being of coastal communities within a sustainable blue economy framework.

Research Results related to the Effect of Industrialisation

Interviews with fishers and stakeholders in the north coast of Java revealed significant impacts of industrialisation on their sustainable livelihoods. Fishers stated that industrialisation has led to a decline in the quality of aquatic habitats, which has a direct impact on fish catches. They reported that industrial pollution and land use change have reduced fish species diversity and reduced available fish stocks. Some fishers also expressed concerns about declining income due to declining catches and increasing operational costs. In addition, interviews with local authorities revealed limited efforts to regulate and manage the environmental impacts of industrialisation, as well as a lack of consistent law enforcement against destructive industrial practices. This reflects the urgent need for more effective policies and sustainable management to protect fishers' livelihoods and aquatic ecosystems.

Table 3. Research Result Data

PARAMETERS	BEFORE INDUSTRIALISATION	AFTER INDUSTRIALISATION	PERCENTAGE CHANGE
Total Fish Stock (Tonnes)	2,500	1,800	**-28%**
Average Catch Per Vessel (Kg)	200	140	**-30%**
Habitat Quality (Quality Index)	8.0	5.5	**-31%**
Fishermen's Income (IDR Million/Year)	50	35	**-30%**
Operating Costs (IDR Million/Year)	20	25	**+25%**
Number of Law Enforcement Activities	**12**	**8**	**-33%**

The table above provides quantitative data that is very useful for understanding the impact of industrialisation on the fisheries sector in the north coast of Java. The data includes several important parameters that show how industrialisation has affected fish stocks, catches, habitat quality, and economic and law enforcement conditions.

The data shows a decline in fish stocks from 2,500 tonnes before industrialisation to 1,800 tonnes after industrialisation, representing a 28% decrease. This decline is a key indicator of the reduced capacity of waters to support healthy fish populations. The catch per vessel also experienced a significant decline, from 200kg to 140kg, with a percentage decline of 30%. This suggests that while the amount of fishing effort may have remained or even increased, fishers are catching less and less. This decline in catch has

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implications for the sustainability of the fishery, indicating that fish stocks are not able to recover quickly enough to meet existing catch levels.

The habitat quality index dropped from 8.0 to 5.5, a 31% decrease. This decline in habitat quality reflects the impact of environmental degradation due to industrialisation, such as pollution, coral reef destruction and land use change. Disturbed habitats result in reduced species diversity and reduced ecosystem capacity to support fish life. Poor habitat quality affects fish reproduction and growth processes, which in turn contributes to declining fish stocks and catches.

The decline in fishermen's income from IDR 50 million per year to IDR 35 million represents a 30% drop, reflecting the direct impact of declining catches on their economic well-being. This decrease in income can cause financial hardship for fishing families, who depend on fish catches for their livelihoods. In addition, operational costs increased from IDR 20 million to IDR 25 million, with a 25% increase, indicating that fishers have to spend more money on fishing operations, including fuel, boat maintenance, and fishing gear. These rising costs exacerbate the impact of declining income and increase economic pressure on coastal communities.

The data shows a decrease in the number of law enforcement activities from 12 to 8, or a decrease of 33%. This decrease suggests that monitoring and enforcement of environmentally damaging industry practices is not effective enough. Limitations in law enforcement can lead to undetected violations and disregard for existing environmental regulations, exacerbating ecosystem damage and negative impacts on fish stocks. The lack of enforcement also indicates an urgent need to increase monitoring and enforcement efforts to protect the environment and support fisheries sustainability.

Overall, the data presented in the table shows that industrialisation has had a significant negative impact on the fisheries sector in the north coast of Java. Declining fish stocks and catch per vessel, degraded habitat quality, and economic challenges faced by fishers all illustrate the widespread impacts of industrialisation. Lack of law enforcement also exacerbates these conditions, indicating the need for more effective policies and actions to manage the impacts of industrialisation and ensure the sustainability of fisheries resources and the well-being of coastal communities.

Likewise, the income of fishermen has an impact on industrialisation. The following table shows the average landings of fish stocks and fishing effort of coastal fishermen on Java Island from 2010 to 2023. This data provides an overview of the trend of fish landings as well as the level of fishing effort made by fishermen.

Table 4. Overview of Fish Landing Trends as Well as the Level of Fishing Effort Undertaken by Fishermen

Year	Average Fish Stock Landings (Tonnes)	Fishing Effort (Days/Weeks)
2010	85,000	5.2
2011	83,500	5.3
2012	81,200	5.4
2013	78,700	5.5
2014	76,300	5.7
2015	74,900	5.8
2016	73,500	5.9
2017	71,800	6.0
2018	70,300	6.2
2019	69,100	6.4
2020	67,800	6.5
2021	66,500	6.7
2022	65,200	6.8

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2023	64,000	7.0

Description

Average Fish Stock Landings (Tonnes): This is the average amount of fish caught and landed by fishermen each year.

Fishing Effort (Days/Week): Indicates how often fishermen fish in a week, reflecting the intensity of fishing effort.

The table shows a gradual decline in average landings of fish stocks, while fishing effort increased, indicating that fishers have to work harder to obtain catches similar to previous years. This could signal pressure on fish stocks in the coastal waters of Java Island.

In recent years, data shows a gradual decline in the average landings of fish stocks in the coastal waters of Java Island. This phenomenon indicates that the amount of fish caught per unit of effort is declining. This is manifested in a significant decline in total catch, despite a consistent increase in fishing effort, measured in terms of number of vessels, number of days at sea and fishing gear. This decline illustrates the great challenge faced by fishers, who have to work harder to obtain catches similar to previous years.

Increases in fishing effort are often not matched by increases in catch. When fishers have to spend more time and effort to achieve the same yield, this indicates a pressure on available fish stocks. In other words, while the amount of fishing effort is increasing, the amount of fish that can be caught is decreasing, which may be due to overfishing or habitat degradation. This underscores an imbalance in the aquatic ecosystem system, where high fishing activity is not matched by adequate regeneration of fish stocks.

Declining fish stocks in coastal Java Island not only affect fishers directly, but also have wider implications for ecosystems and local economies. Declining fish numbers can affect the stability of marine ecosystems, including predator and forage species that depend on declining fish stocks. In addition, the income of fishers who depend on fish catches as their main livelihood will be depressed, which can impact the economic well-being of coastal communities. Declining catches can lead to poverty and local economic instability, worsening social and economic conditions in the area.

This phenomenon of gradual decline could signal that fish stocks in the coastal waters of Java Island are under significant pressure. Various factors, such as overfishing, habitat destruction, climate change and pollution, may contribute to the decline of fish stocks. To address this issue, more intensive monitoring and more sustainable management of fisheries resources are required. Measures such as fishing quota restrictions, habitat rehabilitation, and law enforcement against unsustainable fishing practices may be necessary to ensure that fish stocks can recover and remain available for future generations.

To ensure the sustainability of fish resources and the well-being of fishing communities, sustainable management is key. An ecosystem-based approach involving fishers, government and scientists needs to be implemented to understand fish stock dynamics and develop effective management strategies. This includes the establishment of marine protection zones, strict surveillance and enforcement, and continuous research and monitoring. Implementing these measures is expected to reduce pressure on fish stocks and help achieve a better balance between fishing effort and the sustainability of coastal aquatic ecosystems.

Discussion

Blue Economy to Sustainable Livelihoods

Blue Economy is a concept that promotes the sustainable utilisation of marine resources with the aim to support economic growth, improve community welfare, and maintain the health of marine ecosystems. The concept covers various sectors such as fisheries, aquaculture, marine tourism and renewable energy. In the

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coastal areas of Java's North Coast, the blue economy is expected to support sustainable livelihoods for coastal communities that rely heavily on fisheries as their main source of livelihood (World Bank, 2017). Blue Economy offers a sustainable approach to fisheries management, emphasising the importance of conservation and efficient use of marine resources. In the North Coast of Java, applying blue economy principles can increase fish catches by reducing overfishing, protecting critical habitats such as coral reefs and mangroves, and promoting environmentally friendly fishing techniques (Bennett et al., 2020). This is important to ensure that fish stocks remain healthy and able to sustainably support fishers' livelihoods.

The application of blue economy principles in fisheries on the North Coast of Java involves several key strategies, including the management of marine protected areas, the reduction of waste

and pollution, and the development of sustainable fishing practices. For example, the implementation of fishing quota systems and seasonal fishing restrictions can assist in the recovery of fish stocks. Community-based management programmes can also increase fishers' involvement in decision- making and implementation of sustainable practices (Halpern et al., 2015). Although the blue economy concept offers potential solutions, there are several challenges in its implementation on the North Coast of Java. One of the main challenges is resistance from traditional fishers who may feel threatened by changes in fishing practices or new regulations. In addition, limited funds and resources to implement management and monitoring programmes are also significant constraints. Effective implementation requires strong support from the government and relevant agencies, as well as active participation from local communities (OECD, 2020).

Technology can play a key role in supporting the blue economy by providing more efficient tools and methods for fisheries management and conservation. In the North Coast of Java, technologies such as satellite-based monitoring systems, catch reporting applications, and environmentally friendly fishing techniques can assist fishers in implementing sustainable practices. Technology can also assist in monitoring the condition of marine ecosystems and detecting changes that may affect fisheries sustainability (Pauly et al., 2014). Case studies on the North Coast of Java show that implementing a blue economy can provide tangible benefits to coastal communities. For example, some areas have successfully implemented marine protected areas that protect important habitats and increase fish stocks around these areas. In addition, training programmes for fishers in sustainable fishing techniques and marine resource management have shown positive results in improving catches and fishers' welfare (Sustainable Fisheries UW, 2021).

The blue economy can have a positive impact on the social and economic well-being of coastal communities by increasing income and job stability. By adopting sustainable fishing practices, fishers can reduce their reliance on environmentally damaging practices, which in turn can increase their catch and income in the long run. In addition, the blue economy also opens up new opportunities in marine tourism and aquaculture sectors that can expand livelihood options for coastal communities (Pomeroy & Andrew, 2018). The involvement of local communities is crucial in the implementation of the blue economy. Community-based management that involves fishers in the decision-making process can increase the effectiveness of programmes and ensure that practices are appropriate to local needs and conditions. Programmes such as the establishment of conservation area management groups or sustainable fishing groups have been shown to be effective in increasing community participation and commitment to marine resource management (Cohen et al., 2019).

Continuous evaluation and monitoring is an important part of implementing the blue economy. It is important to have a system that monitors and assesses the impacts of the various programmes and policies implemented to ensure that they deliver the expected benefits. Regular data collection and impact analyses can assist in identifying problems or shortcomings in management and making necessary adjustments (Lester et al., 2016). The blue economy offers great potential to support sustainable livelihoods in Java's North Coast by improving fisheries management and protecting marine ecosystems. However, its successful implementation requires a comprehensive and collaborative approach involving all relevant parties. Recommendations for the future include strengthening institutional support for blue economy programmes, increasing technical and financial capacity, and strengthening community engagement in the

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management process. With these measures, the blue economy can significantly contribute to the well-being of coastal communities and the sustainability of marine resources (UNESCO, 2018).

The Effect of Industrialisation on Sustainable Livelihoods

Rapid industrialisation in the coastal areas of Java's North Coast has brought significant changes to sustainable livelihoods, particularly in the fisheries sector. This region, known for its rich fish resources and fisheries-dependent coastal economy, faces major challenges due to the impacts of industrialisation. While industrialisation can drive economic growth, it also has the potential to negatively impact ecosystems and the livelihoods of local fishers. This analysis aims to explore how the industrialisation process affects the sustainability of fishers' livelihoods in the region and offer recommendations for mitigating negative impacts. Industrialisation on Java's North Coast has caused significant changes in the aquatic environment, including pollution, habitat alteration and water quality degradation. Industrial activities such as fish processing, harbours, and factories have increased pollution levels, which have a direct impact on marine ecosystems and water quality. Research by Mulyanto et al. (2021) showed that industrial-derived pollution can damage coral reefs and seagrasses, which are important habitats for various fish species (Mulyanto, et al., 2021).

The decline of fish stocks in the coastal areas of the North Coast of Java is one of the main impacts of industrialisation. Overfishing and habitat destruction caused by industrial activities have reduced the amount of fish available to fishers. Data from the Central Bureau of Statistics (BPS, 2022) shows a sharp decline in fish catches in the area in recent years, which is directly related to industrial activities that destroy fish habitat (BPS, 2022).

The socio-economic impact of industrialisation on fishermen's livelihoods is significant. Fishermen who previously depended on fish catches now face difficulties in obtaining adequate income. According to research by Nurhadi et al. (2020), changes in fishing patterns and declining catches have led to declining incomes and increasing poverty among coastal communities (Nurhadi, et al., 2020). The welfare of fishers affected by industrialisation has also declined. The study by Setiawan et al. (2023) revealed that declining fish catches and increased operational costs due to pollution and habitat destruction have negatively impacted the well-being of fishers, resulting in decreased quality of life and increased economic instability (Setiawan et al, 2023).

To address the negative impacts of industrialisation, several resource management initiatives have been implemented. An ecosystem-based approach involving strict regulation of industrial activities and the establishment of marine protection zones was proposed as a solution to reduce the impacts of pollution and overfishing. Research by Wijaya et al. (2022) showed that the implementation of marine protected areas can help restore fish stocks and improve the sustainability of fishers' livelihoods (Wijaya, et al., 2022). Effective policies and regulations are critical to managing the impacts of industrialisation. Strict environmental regulations and supervision of industrial activities are needed to reduce negative impacts on fisheries. According to research by Kartika et al. (2021), policy implementation that involves local communities and industry players can improve the effectiveness of fisheries resource management and livelihood sustainability (Kartika, et al., 2021).

Collaboration between the government, industry sector and fishing communities is key to achieving sustainable management. Research by Arifin et al. (2023) emphasises the importance of involving all stakeholders in designing and implementing policies that strike a balance between industrial development and environmental protection (Arifin, et al., 2023). This collaboration can help align economic and environmental goals to achieve sustainable outcomes.

International case studies provide additional insights into how other countries are dealing with similar challenges. For example, the experience of Scandinavian countries in managing the impacts of industrialisation on fisheries suggests that ecosystem-based policies and support for technological innovation can reduce negative impacts and promote sustainability (Hansen & Jakobsen, 2022). Lessons from this case study can be applied to improve fisheries management on the North Coast of Java.

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Overall, industrialisation has had a significant impact on the sustainable livelihoods of fishers on the North Coast of Java. Declining fish stocks, habitat destruction, and declining fishers' welfare are some of the main impacts that need to be addressed. Recommendations for mitigation include the implementation of ecosystem-based management policies, collaboration between stakeholders, and the adoption of environmentally friendly industrial practices. With the right approach, it is expected that fisheries sustainability and fishers' welfare can be improved.

Correlating Blue Economy and Industrialisation's Impact on Sustainable Livelihoods

The blue economy, as a concept that focuses on the sustainable use of marine resources, aims to support economic growth while maintaining the health of marine ecosystems. It involves various sectors, including fisheries, tourism and renewable energy, with an approach that balances economic growth and environmental protection (Barbier, 2017). However, coastal industrialisation, such as infrastructure development and expansion of the fishing industry, often faces challenges in maintaining the sustainability of livelihoods dependent on marine resources. The blue economy seeks to create synergies between economic activity and environmental conservation. In the context of fisheries, this approach aims to improve fishing efficiency and habitat maintenance while promoting the well-being of coastal communities (OECD, 2016). Blue economy implementation often includes ecosystem-based resource management and regulations to prevent overfishing and habitat destruction. As such, the blue economy can provide a basis for sustainable development that involves maintaining marine biodiversity and improving local economies.

Coastal industrialisation, such as the construction of ports, fish processing plants and expansion of the fishing industry, can have significant impacts on the livelihoods of traditional fishers. On the North Coast of Java, increased industrial activity often leads to habitat degradation, marine pollution and space use conflicts between industrial activities and traditional fisheries (Miller et al., 2015). Infrastructure development can change fishing patterns and reduce fishers' access to their traditional catch areas. In addition to environmental impacts, industrialisation can affect fishers' livelihoods socially and economically. Declining fish stocks and a shift to industrial activities can reduce fishers' incomes and increase dependence on employment in the industrial sector (Cinner et al., 2018). The economic well-being of coastal communities may suffer if fishers do not have the skills or access to switch to alternative employment. In the case of Java's North Coast, these changes can result in social and economic instability that affects the quality of life of coastal communities.

To address these challenges, community-based management is often proposed as a solution. This approach involves fishers in decision-making processes and resource management, allowing them to contribute to policies that affect their livelihoods (Bertram & Vivier, 2020). In the North Coast of Java, strengthening fishers' capacity and increasing engagement in fisheries management can help balance the needs of industry with the protection of marine resources. The North Coast of Java case study shows how industrialisation and the blue economy can interact. In this region, the expansion of the fishing industry and port development has led to significant changes in marine ecosystems and fishers' livelihoods. Research by Purnomo (2022) identified that although industrialisation increases the efficiency of fish production, the environmental and social impacts of these changes need to be carefully managed to ensure the sustainability of coastal livelihoods.

To address the challenges faced by coastal communities, several management strategies can be implemented. These include the development of marine protected zones, the implementation of ecosystem-based management policies, and the promotion of environmentally friendly technologies (UNEP, 2018). In the North Coast of Java, the integration of these strategies in development plans can help mitigate the negative impacts of industrialisation and ensure that the blue economy can contribute to livelihood sustainability.

Collaboration between government, industry and local communities is key to achieving sustainability in fisheries management. On the North Coast of Java, cooperation between the public and private sectors, along with the active engagement of fishing communities, can help identify balanced solutions to address

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the impacts of industrialisation (Smith & Pretty, 2019). With a collaborative approach, all parties can work towards the common goal of protecting marine ecosystems and supporting sustainable livelihoods.

The blue economy offers opportunities for innovation that can support sustainable management and fishers' livelihoods. New technologies in fisheries monitoring, more environmentally friendly fishing methods and data-driven solutions can help improve efficiency and sustainability (FAO, 2021). On the North Coast of Java, implementing these innovations could help optimise fish catches while minimising the environmental impacts of industrialisation.

In conclusion, the relationship between the blue economy and industrialisation requires a careful approach to ensure the sustainability of fishers' livelihoods. In the North Coast of Java, the integration of blue economy principles in industrial planning and fisheries management can help strike a balance between economic growth and environmental protection. Recommendations for the future include strengthening sustainable management policies, increasing community engagement, and adopting technological innovations to support long-term sustainability.

Conclusion

This research shows that the blue economy has enormous potential in supporting sustainable livelihoods in the coastal areas of the north coast of Java. The blue economy concept, which focuses on the sustainable use of marine resources, can increase the productivity of the fisheries sector and other related sectors, such as coastal tourism and aquaculture. By integrating sustainability principles into blue economy policies and practices, there is an opportunity to improve the economic conditions of coastal communities on the north coast of Java while conserving marine ecosystems.

The process of industrialisation on the north coast of Java Island has had a significant impact on fishers' livelihoods and fisheries ecosystems. This industrialisation, including the construction of ports, industrial estates and increased industrial activity, often results in the degradation of fisheries habitats and overfishing. This research identified that there is a decline in fish stocks and habitat destruction caused by industrialisation, which affects the ability of fishers to obtain adequate fish catches.

Managerial Implications

Based on the findings of this study, managerial implications regarding the Blue Economy and the Effect of Industrialisation on Sustainable Livelihoods: A Case Study of Fisheries in the North Coastal Region of Java shows that stakeholders, including local governments, fishing companies, and local communities, need to increase collaboration in the implementation of blue economy principles. The management of fishing companies should adopt strategies that focus not only on increasing production, but also on the sustainability of marine resources and the protection of coastal ecosystems.

In addition, industry managers need to consider the long-term impacts of industrialisation on the well-being of local communities, by integrating sustainable economic empowerment programmes, such as skills training for fishers and livelihood diversification. This can help reduce communities' dependence on limited marine products, and ensure that industrialisation does not worsen environmental conditions or their livelihoods.

Finally, it is important for fisheries sector management to increase investment in environmentally friendly technologies and innovations that support production efficiency without harming ecosystems. These measures will support sustainable development in coastal areas and improve the competitiveness of Indonesia's fisheries sector in the global market, while maintaining a balance between economic growth and environmental sustainability.

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