



Blue Economy Model to Increasing Coastal Community Income, Employment, and GRDP in South Sulawesi

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Abstract. The blue economy is emerging as a key development concept and business model driving Indonesia's new economy. It is expected to enhance economic growth, social welfare, and ecological sustainability. This study analyzes the role of the blue economy, particularly the fisheries sector, in increasing coastal community income, employment absorption, and regional economic growth (GRDP) in South Sulawesi. Using secondary data from the Central Bureau of Statistics (BPS) and the Fisheries Statistics Report of South Sulawesi (2012–2023), this research employs a dynamic systems approach. Simulations are conducted under a Business As Usual (BAU) scenario and two policy scenarios: expanding conservation areas and providing production assistance. The results show that the blue economy model effectively sustains fish stocks, maintaining levels 6.44% higher than current conditions. It also boosts catch yields by 10.03% and aquaculture production by 6.21%. Additionally, the model contributes to a 6.56% increase in both the fisheries sector's GRDP and per capita GRDP. In terms of employment, the model facilitates job absorption of 59,244 workers, or approximately 7.99%. These findings suggest that the blue economy model is a viable strategy for enhancing coastal community welfare, employment, and regional economic growth while ensuring sustainable fisheries management.

Keywords : blue economy, coastal community, GRDP, employment, dynamic system

1. Introduction

Blue economy is understood as an economic concept that focuses on the sustainable utilization of marine resources for economic growth, the enhancement of social welfare, and the preservation of the marine environment [1]. The blue economy aims to create an optimal balance between marine-based economic activities, providing welfare for the community, and ensuring the sustainability of marine ecosystems for future generations [2]. The blue economy is a sustainable development approach that focuses on utilizing the economic potential based on marine resources while maintaining the continuity of marine ecosystems themselves, ensuring that utilization can be done optimally and sustainably. This includes various sectors, such as the

fisheries industry (capture fisheries, aquaculture, ice plants, cold storage, and food and beverage industries based on marine resources), tourism (especially natural tourism), maritime transport, port warehousing, as well as emerging activities such as offshore renewable energy, aquaculture, and marine biotechnology [3]. The World Bank defines the blue economy as the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health. Additionally, the blue economy concept has evolved to include a stronger emphasis on sustainability, with some regions referring to it as the sustainable blue economy [4].

However, the implementation and interpretation of the blue economy can vary across different regions and contexts. For example, in China, the blue economy is viewed as an opportunity to promote modernization from economic, geopolitical, and ecological perspectives, presenting unique challenges for global ocean governance [5]. In Indonesia, the blue economy concept serves as a framework for development, representing one of the contemporary development models, defined as national development that relies on marine resources conducted sustainably. The National Development Planning Agency (Bappenas) has established a framework for Indonesia's Blue Economy Development for the transformation of Indonesia's economy, including the foundational pillar of the maritime sector, which is reflected in the National Long-Term Development Plan (RPJPN) 2005-2025, for a strong, sovereign, and advanced nation. In the Philippines, the blue economy offers a model for the utilization of marine resources that focuses on policy challenges and opportunities in the maritime sector [6]. Similarly, Seychelles in East Africa, an island nation, is implementing blue economy development by mapping it as a new development pathway [7]. In Thailand, blue economy development is utilized as a tool or approach to guide the future of Thailand based on its past and present [8]. In Nigeria, the blue economy development approach aims to achieve the objectives of the maritime sector [9]. Finally, the blue economy represents a holistic approach to marine-based economic development that balances growth with environmental preservation [10]. This offers potential solutions to various global challenges, including food security, job creation, and climate change mitigation [11]. However, the successful implementation of the blue economy requires addressing issues such as pollution, overfishing, and inadequate regulatory frameworks [12, 13]. As the concept continues to evolve, there is a growing recognition of the need to integrate circular economy principles and encourage collaboration among various sectors to achieve a truly sustainable blue economy [14].

The blue economy is one of the highly potential sectors in Indonesia. The fisheries sector, in particular, and the blue economy sector in general play a significant role in many economies, contributing to national income, job creation, and food security [15]. In Indonesia, state revenues from the fisheries sector have increased significantly since the enactment of illegal fishing policies, with non-tax state revenue (PNBP) rising from IDR 77 billion in 2015 to IDR 491.18 billion in 2017 [16]. Namun demikian, the fisheries sector can provide substantial income, its performance varies across regions and is influenced by factors such as government policies, environmental conditions, and market demands. To address income challenges,

strategies such as sustainable fishing practices, ecosystem-based management, and capacity building for fishermen are being implemented in various countries [17]. These efforts aim to optimize the potential of the fisheries sector and provide significant economic, social, and environmental benefits.

South Sulawesi Province is one of the regions in Indonesia that has extensive coastal and marine areas. The areas cover Makassar Strait, Flores Sea, and Bone Bay, as well as small islands in the Spermonde and Takabonerete areas, with a coastline of around 1,980 km and seawater area of around 48,000 km² [18]. Based on data from the Central Bureau of Statistics (BPS), the production of the marine capture fisheries sub-sector in South Sulawesi is relatively large, but its growth is in a stagnant stage. From 2018 to 2020, the average production was 353.94 tons per year, with a contribution of only 5.22% to the national production. Thus, this sector is often marginalized compared to other national development sectors. On the other hand, the development of the fisheries sector must be conducted optimally and sustainably, starting from upstream, including sustainability and feasibility analysis of the skipjack (*Katsuwonus pelamis*) [19], model of skipjack (*Katsuwonus pelamis*) production based on social and economic aspects [20], the economic potential of blood cockles [21], capture fishery management [22], down to the downstream, including infrastructure, specifically the improvement of infrastructure at the Paotere Fish Landing Base (TPI) [23], designing management of sustainable shrimp cultivation [24], and strengthening the social framework [25].

To that end, it is important to conduct various research on how the blue economy sector can serve as one of the sustainable development models to drive regional and national economic growth, create jobs, reduce unemployment, and increase the income of coastal communities, especially to achieve shared prosperity. This research aims to dynamically analyze (changes over time) the largest blue economy sector in South Sulawesi, namely the fisheries sector, in driving increasing coastal community income, employment absorption, and regional economic growth (GRDP) in South Sulawesi.

2. Method

2.1 Kinds and sources of data

The type of data in this research is secondary data, including: GRDP data for the fisheries sector in South Sulawesi, data on catch production from the sea (tons), data on marine aquaculture production including pond aquaculture production, data on the coastal population in South Sulawesi, including the number of fishermen and fish farmers, data on fish stocks or the potential for capture fisheries in South Sulawesi, data on the area of aquaculture and potential aquaculture areas in South Sulawesi, and data on the environmental carrying capacity of marine waters. These data were obtained from the Central Bureau of Statistics of South Sulawesi Province and the Fisheries Statistics of South Sulawesi. All the data used in this research are official data released by the government over a period of 12 years (2012-2023).

2.2 Collecting data

The data collection method used in this research is the literature review method, which involves the exploration of statistical data on fisheries in South Sulawesi and the review of related research findings. A literature review is a data collection method conducted by examining relevant literature or written sources related to the research topic [26], or by gathering data that has already been made available and collected previously by other individuals/institutions for specific purposes.

2.3 Data analysis

The data analysis used in this research is a dynamic systems analysis approach. Dynamic systems analysis is a tool that can be used to model complex phenomena, such as in macro and microeconomic research, including how to optimally utilize fisheries resources to drive economic growth, as seen in this research blue economy policy model for encouraging regional growth in South Sulawesi [2], and research fostering sustainable growth through the blue economy: balancing prosperity and marine conservation [27]. Dynamic systems were introduced by Jay W. Forrester in an essay titled 'System Dynamics, System Thinking, and Soft OR.' Initially, dynamic systems were used to solve problems in the industrial world. Dynamic systems later evolved to address various complex and dynamic issues, such as population growth and development, supply chains, forest management, climate change, and various other complex development problems. Furthermore, it is stated that dynamic systems can represent complex and dynamic actual conditions in a simpler form and examine the behavior of the components within the system to approach real conditions [28]. According [29] Dynamic systems represent a comprehensive, dynamic, and integrated systems approach that can simplify complex and intricate problems without eliminating the essential elements of the object of concern.

Dynamic systems relate to questions about the dynamics of complex systems, specifically the patterns of behavior generated by the system as time changes. The main emphasis in the use of dynamic systems is on the behavior that emerges from the structure of the model that is built. The behavior arising from the model will reflect the behavior of the real world; therefore, the closer the model is to reality, the better the model. Furthermore, it is stated that the formulation in dynamic systems is a formulation of problems that describes feedback relationships or feedback systems, which are typically depicted in circles of cause and effect (causality) or feedback loops (causal loops) [29]. This system is dynamic because it changes over time and reaches stability after the objectives are achieved [30]. According [28] The main assumption in dynamic systems is that persistent or continuous dynamic tendencies in a complex system originate from the causal structure that forms the system. Furthermore, it is stated that there are two important aspects to consider in the development of dynamic system models: 1) the model must represent the conditions of the real world, and 2) the model must be specific to solve certain problems. In addition, there are two main characteristics of dynamic systems: 1) the presence of

cause-and-effect relationships (causality), and 2) the presence of feedback. The structure of the research model is detailed in the following causal loop diagram:

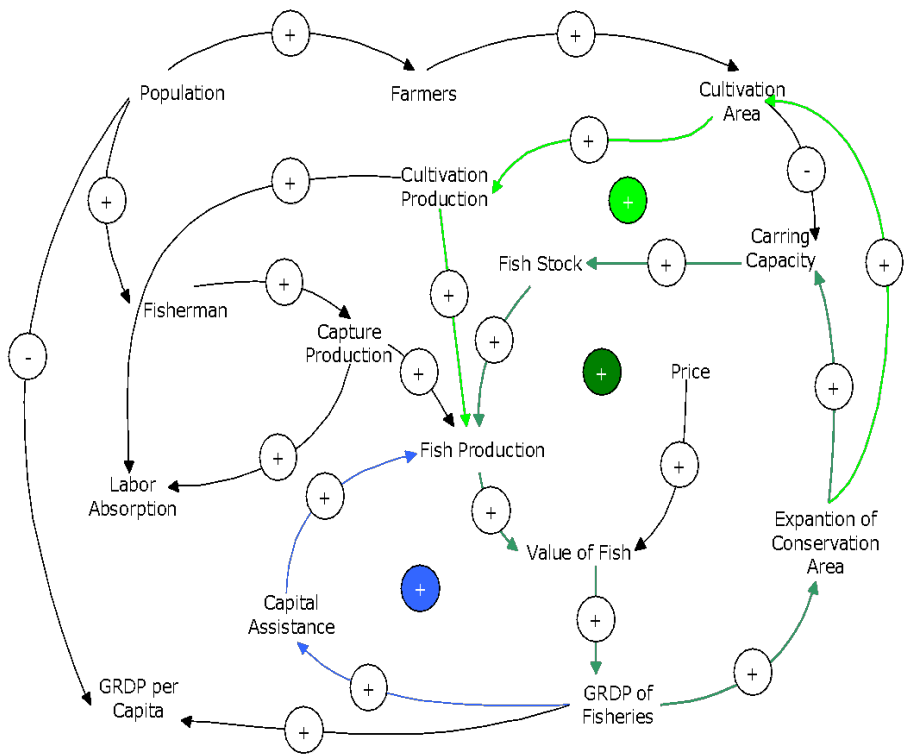


Fig. 1. Stock Flow Diagram

The model built is based on the assumption of optimizing the fisheries sector in South Sulawesi in two subsectors: the capture fisheries subsector and the aquaculture subsector, including marine aquaculture and pond aquaculture in coastal areas. The optimization of the fisheries sector will encourage employment absorption, increase income (GRDP per capita), and drive regional economic growth (GRDP of South Sulawesi). The causal loop diagram is shown in Figure 1, It shows that the increase in fishermen and fish farmers is driven by population and production factors, where higher populations and catch results lead to greater employment absorption in the sector. Conversely, the number of fishermen and fish farmers will stimulate an increase in fisheries production, both from catches in the sea and from marine and pond aquaculture production. Furthermore, this increase in production will enhance the contribution of the fisheries sector to the GRDP. To ensure that the optimization of production in the fisheries sector is sustainable, policy scenarios are implemented: 1) expansion of conservation areas to enhance environmental carrying capacity, and 2) increasing capital assistance to improve production factors. These two policy scenarios are expected to support the sustainable optimization program of the fisheries sector in South Sulawesi.

Stock Flow Diagram is a graphical representation used in dynamic systems to illustrate how stocks change over time due to inflows and outflows from the system. This diagram is used to model complex systems and describe the interactions between various elements within the system. The stock is represented by the variables of population (people), area of aquaculture (hectares), aquaculture production (tons), fish stocks (tons), catch (tons), and environmental carrying capacity (tons). Furthermore, the flow is depicted by the rates of population (people/year), area of aquaculture (hectares/year), catch (tons/year), aquaculture production (tons/year), and environmental carrying capacity (tons/year). Meanwhile, the target output of the model are; 1) The increase in the income of coastal communities is represented by the variables of fishermen and fish farmers' income, as well as the per capita income of coastal communities (obtained from the GRDP of the fisheries sector divided by the coastal population), 2) the increase in GRDP of the fisheries sector (derived from the total revenue of the fisheries sector, sourced from the revenue of capture fisheries and revenue from marine and pond aquaculture), and 3) employment absorption (obtained from the increase in production that drives an increase in the number of workers). Meanwhile, the policy scenarios are represented by auxiliary variables, including: the expansion of conservation areas (hectares), and the provision of production assistance. Both are obtained from the allocation of the budget from the contribution of the GRDP of the fisheries sector, amounting to 1-5% per year.

3. Results and Discussion

3.1 Fish Stock Model

The fish stock model is a model that describes the behavior of fish stocks. This model is based on the initial fish stock, which is the potential capture fisheries in South Sulawesi, amounting to 1,074,147 tons, including: large pelagic fish, small pelagic fish, demersal fish, crustaceans, and gastropods. Model simulations are conducted with 2 scenarios, namely: 1) the Business As Usual (BAU) scenario, and 2) the policy scenario, which includes: the policy scenario for expanding conservation areas to enhance environmental carrying capacity in maintaining resource sustainability, and the policy scenario for providing assistance in increasing production capacity to boost capture fisheries production and aquaculture production. The simulations are conducted to promote; 1) Optimal increase in fisheries production to enhance the GRDP of the fisheries sector, 2) Increase in community income (fishermen and fish farmers) and improvement in per capita income of coastal communities, and 3) Increase in employment absorption in the capture fisheries and aquaculture sectors. The following is an illustration of the fish stock condition from the simulations conducted.

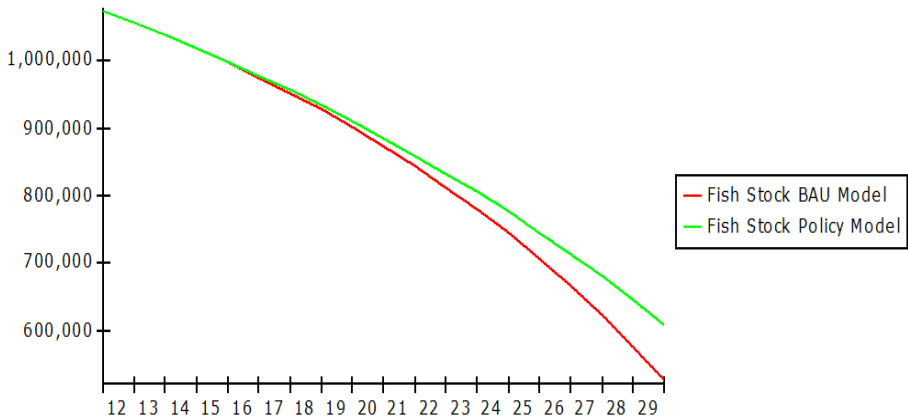


Fig. 2. Fish stock models

It can be seen that between 2012 and 2029, the fish stock shows a significant decline, especially in the BAU model, where this scenario is a simulation of the existing model that is then simulated without any changes to the values or variables, but only simulates under the current conditions by extending the time in the simulation to a longer duration (into the future). The results of the BAU model simulation show a more drastic decline in fish stock compared to the policy model scenario, where the fish stock is better maintained, although it still experiences a decrease. The data indicates that the fish stock from the existing model simulation is 644,874.89 tons, representing a decline of 498,427.45 tons or approximately 46.40%. This amount is higher compared to the decline in fish stock in the policy scenario model, which decreased by 429,272.11 tons or approximately 39.96%. This occurs because of the policy scenario for sustainable fish resource management, including the policy of expanding conservation areas, which will enhance the environmental carrying capacity for fish growth and its ecosystem. This policy is capable of better maintaining fish stocks by approximately 6.44%. Thus, this policy scenario can serve as one of the alternative policies for the sustainable optimization of fishery resources.

The decline in fish stocks is an inevitability. Although fishery resources are renewable, high fishing pressure, habitat destruction, and global climate factors are the main triggers for the significant decline in global fish stocks and also in Indonesia. The decline in fish stocks has become a serious issue in various waters around the world, including Indonesia. Several studies indicate a trend of declining productivity and biodiversity of fish resources in various regions. For example; In the waters of Jakarta Bay and the Thousand Islands, there has been a decline in CPUE (Catch Per Unit Effort) and changes in the composition of catches, indicating overfishing [31]. This is caused by habitat degradation and water pollution, which impact fish populations and species diversity. A study along the Kenyan coast also showed a trend of declining productivity and biodiversity of fish resources during the period from 2014 to 2019, with 84.9% of respondents reporting a decrease in catch and

70.6% reporting a decline in fish abundance and diversity [32]. Catches from Australian wild fisheries decreased by 31% over the past decade. The biomass of large fishes observed on underwater transects decreased significantly over the same period on fished reefs (36% decline) and in marine park zones that allow limited fishing (18% decline), but with a negligible overall change in no-fishing marine reserves. Populations of exploited fishes generally rose within marine reserves and declined outside the reserves, whereas unexploited species showed little difference in population trends within or outside reserves. Another significant factor is that several research findings indicate that recreational fishing also has a significant impact on fish stock recovery. For instance, in Kaunas Reservoir, Lithuania, recreational fishing has slowed the recovery of predator species such as zander and perch, while less frequently caught species like roach have experienced rapid recovery [33].

For future fishing activities, the sustainability of fish resources (fish stocks) must always be considered, taking into account environmental variables (carrying capacity). The model described is capable of reducing the rate of resource degradation alongside the increase in production that occurs. This model is regarded as a good model for achieving optimal and sustainable utilization of fish resources, as it incorporates environmental factors, including the expansion of conservation areas to enhance environmental carrying capacity. This aligns with the need to address the issue of declining fish stocks through an ecosystem-based management approach that considers environmental factors and trophic interactions [34]. The establishment of effective marine protected areas is also recommended to aid in the recovery of fish stocks and to maintain marine biodiversity [35].

3.2 Fisheries Production Model

The production model is a model that describes the level of fisheries production, both capture fisheries and aquaculture production, measured in tons. The production model is constructed with the interrelationship of variables such as the number of fishermen and fish farmers (individuals), income (rupiah), fish stocks (tons), and the area of aquaculture (hectares). Fisheries production in South Sulawesi is predominantly dominated by the aquaculture subsector, which includes seaweed cultivation, floating net cages (KJA), and ponds. The total aquaculture production in 2023 reached 5,246,586 tons. This figure is significantly higher than the capture fisheries production, which is 465,039 tons. The graphical development of production in these two subsectors (capture fisheries and aquaculture) is detailed as follows:

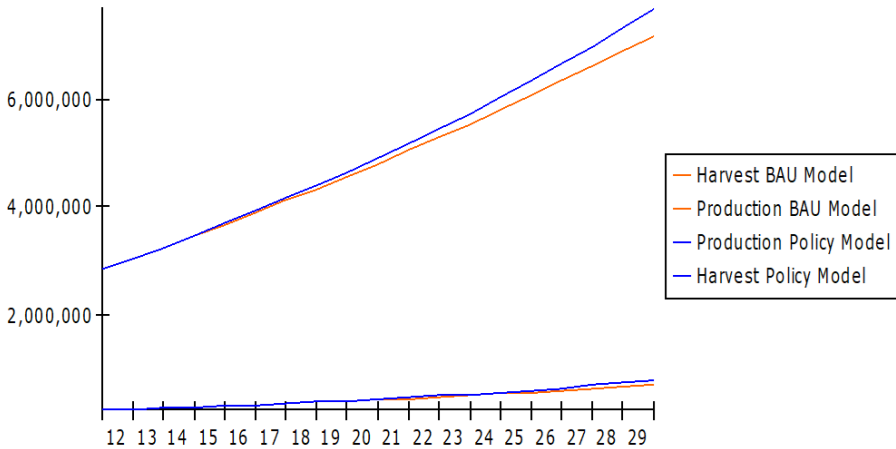


Fig. 3. Fisheries Production

The graph shows that both fisheries subsectors (capture and aquaculture) demonstrate an increase in production from year to year. The results of the BAU model simulation indicate that capture fisheries production will reach 689,154.11 tons in 2029, which is an increase of 69,155.34 tons with the policy model simulation, representing a growth of 10.03% with the policy scenario of conservation area development and the policy scenario of providing production capital assistance. A similar condition occurs in aquaculture production, where the production from the BAU scenario is lower at 6,856,245.61 tons compared to the policy scenario simulation, with total production reaching 7,282,244.56 tons, an increase of 425,998.95 tons or approximately 6.21%. Thus, the simulation of the policy scenario model is considered quite effective in increasing fisheries production, particularly in the capture fisheries sector.

Aquaculture has a much higher potential for sustainability compared to capture fisheries. The main constraint in the sustainability of capture fisheries is the continuous decline in natural fish stocks. Meanwhile, aquaculture provides a much greater certainty of production sustainability. Aquaculture has emerged as an important sector to address the insufficiency of capture fisheries as wild fish stocks have been progressively depleted over time [36]. In Singapore, aquaculture production from marine fish farms accounted for 98% of total fish production in 1995, indicating dominance over wild-caught fisheries in that country [37]. Aquaculture has significant potential for growth and development, particularly in meeting increasing demand for fish protein. In Kenya, aquaculture production is projected to reach 20,000 MT/year, representing 10% of total fish production [38]. On the other hand, aquaculture provides other business opportunities. There are opportunities in areas like production of live fish food, marine fish and shellfish larviculture, seaweed farming, cage culture, and integrated fish farming [38]. However, several challenges need to be addressed for sustainable aquaculture development. These include lack of technical assistance, inadequate supply of quality fish seed and feed, incomplete policies, low research funding [38], and environmental concerns like pond effluent management and introduction of non-native species [39].

Climate change impacts like floods and droughts also pose threats to aquaculture sustainability [39]. To realize aquaculture's potential, a multi-pronged approach is needed. This includes developing cogent policies, providing sustainable subsidies, intensive training of human resources, strengthening disease surveillance, exploring alternative fish feeds, improving fingerling production, and developing export markets [40]. Additionally, adopting environmentally-friendly practices like using natural pesticides [41] and implementing community-based aquaculture models [42] can promote sustainable development. Integrating ecological perspectives into policies that balance fishing, aquaculture and conservation will be crucial for a viable future of marine ecosystems and aquaculture [43].

3.3 Fisheries GRDP Model

The GRDP model is a model that describes the level of fisheries production, both capture fisheries and aquaculture production, measured in tons. The production model is built from the leverage factors of fisheries production value, derived from two main variables: fisheries production (tons) and fish prices (rupiah per kilogram). In this model, the commodity prices are assumed to be the same for both capture fisheries and aquaculture.

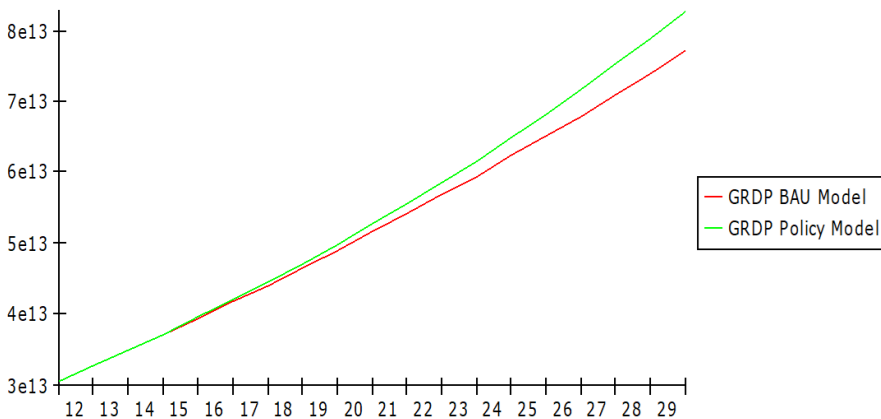


Fig. 4. GRDP of fisheries sector in South Sulawesi

The simulation results show that the GRDP of the fisheries sector continues to increase along with the rise in fisheries production. The simulation results from the BAU scenario appear to be lower compared to the results of the policy scenario simulation. It is evident that the GRDP value of the fisheries sector from the BAU model simulation is 73,944,917,225,320.30 rupiah, while the GRDP value from the policy model simulation for the year 2029 is 78,797,429,344,655.50 rupiah, representing an increase of 4,852,512,119,335.20 rupiah or approximately 6.56% due to the implementation of fisheries sector management policies, namely the policy for developing conservation areas to enhance environmental carrying capacity, and the policy for providing production capital assistance. This increase in the GRDP of the

fisheries sector is driven by the rise in production from both capture fisheries and aquaculture. The increase in GRDP has a positive impact on the per capita income of the population, particularly for coastal communities.

GRDP per capita in this research is illustrated by the GRDP per capita of the fisheries sector, which represents the average output or production of goods and services per person (individual) in the fisheries sector in South Sulawesi. Below is an illustration of the GRDP per capita of the fisheries sector generated from the dynamic model simulation. GRDP per capita (Gross Regional Domestic Product per capita) is an important economic indicator used to measure the average income and economic development of a region. Several studies have examined the effects of GRDP per capita on various economic factors, such as; research results [44] found that in North Sumatra, GRDP per capita was found to have a negative and significant effect on poverty levels. This suggests that as average incomes increase, poverty tends to decrease in that region. Research results [45] found that in East Kutai Regency, GRDP per capita had a positive and significant effect on Land and Building Tax revenues as well as locally-generated revenue. This indicates that higher average incomes are associated with increased tax collection.

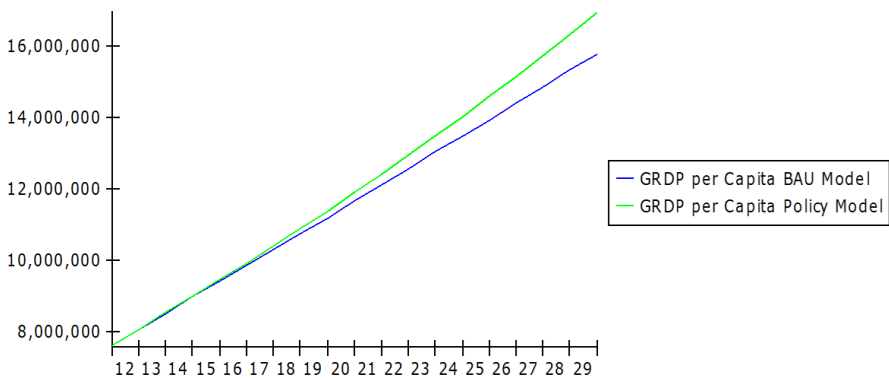


Fig. 5. GRDP per Capita

The results of the dynamic model simulation indicate that GRDP per capita increases in line with the growth of the fisheries sector's GRDP. The results of the BAU model simulation show that the GRDP per capita is 15,313,938.18 rupiah per person per year, or an average of 1,276,161.52 rupiah per month. This represents an increase of approximately 6.56% under the policy model simulation, raising it to 16,318,889.88 rupiah per person per year, or an average of 1,359,907.49 rupiah per month. Based on these results, it appears that the per capita income of coastal communities is relatively low and below the provincial minimum wage (UMP) of South Sulawesi, which is 3,434,298 rupiah per month. Therefore, various constructive and comprehensive efforts are needed to improve the income and welfare of coastal communities.

3.4 Labor Absorption Model

The employment absorption model is a model that describes the behavior (development) of employment absorption levels in the fisheries sector, including capture fisheries as fishermen and aquaculture as fish farmers (pond operators). Employment absorption is one of the important socio-economic indicators in the development of sectors based on natural resources, including the fisheries sector as a part of the blue economy or sectors based on marine resources.

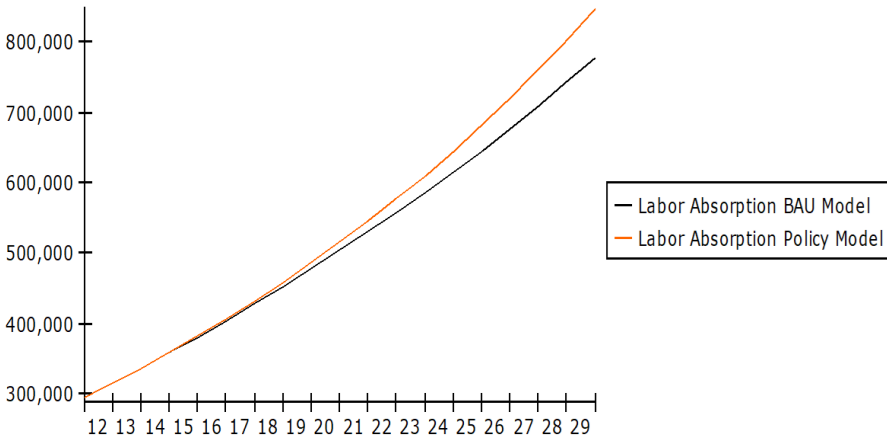


Figure 6. Labor Absorption

The results of the dynamic model simulation indicate that the model exhibits exponential growth over time (year by year). It is evident that the results of the BAU model simulation show a lower employment absorption level of 741,580 people, compared to the employment absorption level from the policy model simulation, which reaches 800,824 people, representing an increase of 59,244 people or approximately 7.99%. The fisheries sector has great potential for employment absorption, but it needs to be managed sustainably. Appropriate policies and legal frameworks are required to optimize this sector's potential in creating jobs [46], considering that high employment absorption also poses challenges. The increase in the number of fishermen leads to uncontrolled fishing and a decline in catch yields [47].

4. Conclusion

The blue economy model is one of the solutions for sustainable development, enhancing economic growth, including the income of coastal communities, promoting social welfare, and preserving natural resources. The simulation results indicate; 1) The blue economy model can better maintain fish stocks, approximately 6.44% compared to existing conditions. 2) The implemented blue economy model can increase catch yields by 10.03% and enhance aquaculture production by about 6.21%.

3) The blue economy model can increase the GRDP of the fisheries sector by 6.56% and also raise per capita GRDP by 6.56%. 4) The blue economy model can absorb 59,244 jobs or approximately 7.99%. Thus, the blue economy model is considered quite effective and relevant in driving increasing coastal community income, employment absorption, and regional economic growth (GRDP) in South Sulawesi, while also promoting social welfare and preserving fish resources.

5. Acknowledgement

The author would like to express sincere appreciation to all parties who have supported and contributed to completing this article entitled Blue Economy Model for Increasing Coastal Community Income, Employment Absorption, and Regional Economic Growth (GRDP) in South Sulawesi. This Research was supported by Center For Education Financial Services (PUSLPADIK Indonesia) and Indonesia Endowment Fund For Education (LPDP Indonesia).

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