Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the AsiaFish model

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\textbf{A B S T R A C T}

This paper explores the seafood sector in Indonesia, using fish supply-demand modeling, with special focus on the growing role of aquaculture in the country’s food portfolio. The paper describes six scenarios for future fish supply–demand dynamics and examines the role of aquaculture growth in fish supply in Indonesia. A business as usual scenario (BAU) assumed exogenous variables of our supply-demand model following historical trends. Five alternative scenarios explored the implications of stagnant capture fisheries; export-oriented growth of aquaculture; domestic-oriented aquaculture growth; slow growth of aquaculture sector; and disease outbreaks to key aquaculture species. The BAU scenario projected that fish supply and demand in Indonesia continues to increase over time and strong aquaculture growth is critical to meet increasing demand for fish. Stagnant capture fisheries resulted in increasing fish prices and decreasing fish consumption. Export-oriented aquaculture growth benefitted fish supply and exports, but also helped lower domestic prices and thus increase consumption. An emphasis on domestic aquaculture commodities increased fish supply, providing best domestic consumption outcomes and lower consumer prices. Slow aquaculture growth reduced fish supply and led to undesirable increases in domestic prices and decreasing domestic consumption as a consequence. Disease outbreaks in shrimp and carp aquaculture resulted in a short-term reduction in aquaculture output and increasing fish prices, lowering fish consumption.

1. Introduction

Indonesia is the second largest fish producer in the world after China, with capture fisheries and aquaculture production, including aquatic plants, estimated at 6.5 and 14.4 million tons, respectively in 2014 [1]. The fisheries sector plays an important role in Indonesia’s economy through income generation, livelihoods diversification, supply of animal proteins, and foreign exchange earnings. The sector contributed 3.1% to the total national gross domestic product (GDP) and 21.0% to the total agricultural GDP, created an estimated 6.4 million direct jobs for Indonesians, earned US$ 4.2 billion dollars from seafood exports in 2012 and provided 54.8% of domestic animal protein supply [2]. Per capita fish consumption in Indonesia is also increasing, with annual consumption per capita going from 21.0 kg in 2003–33.9 kg in 2012 [3].

Fish supply in Indonesia has been growing at a steady rate over the past 50 years, from 0.8 million tons in 1960 to 10.7 million tons in 2014 [1]. Most of these fish still come from wild capture fisheries in inland and marine waters, but fish landings have leveled off over the last decade. Aquaculture has, in turn, become the main driver behind...
fish supply growth in Indonesia in recent years. With an annual growth rate of the aquaculture sector of about 7.7% per year since 1960, the share of farmed fish of total fish production rose from 10.6% in 1960 to 40.2% in 2014 [1]. Indonesia is also considered to have great potential for further aquaculture growth, with more than 17,000 islands and a coastline of about 81,000 km. The Indonesian government has, for example, stated that there is an additional 26 million hectare of suitable land for aquaculture expansion [4].

Total landings from capture fisheries have been increasing at 4.2% per year on average over the past 50 years but has slowed down to 3.1% per year over the past 10 years [1]. By weight, skipjack tuna accounts for the largest portion (7% excl. aquatic plants) of a diverse set of landings [2]. As much as 90 species actually make up 90% of production, including other tunas, scads, mackerels, catfishes, groupers, sharks, squids and bivalves [1]. By monetary value, prepared tuna is the second most important export commodity (7%), following frozen sheries, groupers, sharks, squids and bivalves [1].

Economic development targets (e.g., contribution of shrimp and prawn (27%) which are mainly farmed[1]. Judging from economic development targets for the largest portion (7% excl. aquatic plants) of a diverse set of landings [2]. As much as 90 species actually make up 90% of production, including other tunas, scads, mackerels, catfishes, groupers, sharks, squids and bivalves [1]. By monetary value, prepared tuna is the second most important export commodity (7%), following frozen sheries, groupers, sharks, squids and bivalves [1].

While aquaculture is projected to continue to grow [9–11], its expansion over the past three decades has highlighted a number of social and environmental challenges, including loss of mangrove and wetland ecosystems, pollution of waterways, rendering of edible fish into fish meal and oils for aquaculture diets, marginalized local farmers, increased social tensions and fish disease outbreaks resulting in aquaculture crop failures and income losses [12–19]. With increasing environmental awareness, concerns related to aquaculture development have recently extended to greenhouse gas emissions, acidifying emissions, energy use and water depletion. Increasing stringency of environmental regulation might constrain aquaculture growth as suggested by Abate et al. [20].

In order to sustain the sector’s growth and avoid adverse socio-economic and environmental consequences, the government of Indonesia adopted the concept of blue growth for fisheries and aquaculture in 2014. The action is in line with the Blue Growth Initiative (BGI) for fisheries and aquaculture launched by the Food and Agriculture Organization (FAO) in 2013. According to FAO [21], blue growth is defined as: “Sustainable growth and development emanating from economic activities using living renewable resources of the oceans, wetlands and coastal zones that minimize environmental degradation, biodiversity loss and unsustainable use of aquatic resources, and maximize economic and social benefits”. The concept has become an emerging paradigm for sustainable utilization and management of marine and freshwater resources including fisheries and aquaculture. It has been promoted as an integral part of the oceanic and freshwater development strategies by many international and national organizations, in both developed and developing countries [22]. Though the term ‘blue growth’ is used liberally in national ocean plans, it remains ill-defined in operational terms and subject to different interpretations by interested actors [23]. Successful blue growth strategies require appropriate enabling policies, strong advocacy, innovative financial investments and suitable knowledge transfer mechanisms [22]. In support of the government of Indonesia’s policy vision, this article explores the concept of blue growth, with special focus on aquaculture. Using the supply-demand AsiaFish model, the present article provides projections to build an understanding of the future fish supply-demand situation in Indonesia up to 2030. Specifically, it analyses the implications of business as usual (BAU), and five alternative scenarios (ASs) in terms of key outcomes: fish production, consumption, trade, consumer and producer prices.

The paper highlight future growth trends in the fishery and aquaculture sectors and key social, economic and environmental outcomes associated with these trends, from which more public and private sector actions can be identified for attention in applying the blue growth concept.

2. Methods and data

The objective for this research was to assess the complex interactions of fish supply, demand and trade, as well as their future implications on development outcomes. Food sector supply-demand models are well suited for making such projections, because they take the behavior of stakeholders from multi-markets into account. To date, several partial equilibrium economic models, such as the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) [24] and the AGLINK-COSIMO model, have included fish commodities into their analyses. For instance, in 2003, Delgado [25] used the IMPACT to produce projections of global food fish production, consumption, and trade for the period 1997–2020.

In 2013, the International Food Policy Research Institute (IFPRI), the World Bank, the FAO, and the University of Arkansas at Pine Bluff improved Delgado’s IMPACT fish model to generate the Fish to 2030 report [26] covering a period from 2000 to 2030. A short version of this study provides projections of the global supply, demand and trade of fish products to 2030 was presented in Kobayashi et al. [11]. These global models used the world price of a commodity as the mechanism for establishing equilibrium for national and global fish markets. However, there are limitations found in these models with regards to labor and time costs-effectiveness as well as the disaggregation level for exploring growth options for aquaculture at the country level that we will address in the present study.

The fish sector model (AsiaFish) was developed by Dey et al. [27,28] and has been used extensively to evaluate consequences of changes in technology, fishing effort, incomes, urbanization, export prices, trade policy, and impacts of climate change and related adaptation strategies on fish supply and demand [29,30]. This supply-demand model divides a country’s fish sector into producer, consumer and trade cores. In the producer core, domestic supply equations are derived from the normalized profit function approach and can be differentiated by production category (e.g., capture fisheries, aquaculture, commodity groups, etc.). A shift in a supply function due to technological change, policy change or changes in other quasi-fixed factors is represented by the proportional change of fish supply and captured by a ratio of actual and effective prices (technological index or factor productivity parameter, lambda). In the consumer core, household fish demand functions are derived from a three-stage budgeting framework [31], with household food and fish expenditure functions specified in the first and second stages, and expenditure shares of fish groups specified in the third stage using the quadratic form of the Almost Ideal Demand System (AIDS) [32,33]. The trade core of the model is comprised of fish export supply and import demand functions imposing the Armington assumption [34], a common approach used in computable general equilibrium models (CGE) that treats domestic and foreign goods as differentiated products. Model closure is found by simultaneously equating supply-demand for every fish type declared in the model. Once completed, the model is solved by the Generalized Algebraic Modeling System (GAMS) for the largest portion of total aquaculture production (excl. aquatic plants) of a diverse set of landings [2]. As much as 90 species actually make up 90% of production, including other tunas, scads, mackerels, catfishes, groupers, sharks, squids and bivalves [1].
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