Techno-socio-economic analysis of losses in capture fishery: a case study in Pelabuhan Ratu, Sukabumi, West Java Province

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Abstract. This research was aimed at analyzing factors influencing capture fisheries losses, focusing on technical, social and economic aspects at Pelabuhan Ratu. A case study was undertaken, through a survey involving 40 respondents. These respondents represented groups of fishers, collectors, middlemen, processors and consumers. The questions delivered in the survey was adapted from the Exploratory Fish Loss Assessment Method (EFLAM). Based on this research, the fish loss was detected in Palabuhan Ratu, which amounted to 4.25 % at the fisher level and 5.12 % in the following supply chains, due to some factors. It was found that among the technical factors, the most influential ones were handling of landed fish, fish sortation, fish size, fish shelf life and season. Among economic aspect, factors with the most significant influence were fish price fluctuation and price level; meanwhile, among the social factors, those that had the most significant influence was the revenue distribution system. Based on this, the relevant policy implication of this research was the need for effective programs which covers the development of cold chain and distribution facilities and infrastructure, and an improvement in skills and knowledge of fish derivative product processors.

1. Introduction
Among Indonesian’s prominent production centers, there is Palabuhan Ratu in the Sukabumi District of West Java Province. In 2016, the Palabuhan Ratu’s capture fishery production was recorded at 3,839,057 kg [1]. The main species of fish loaded in Palabuhan Ratu landing place are mainly Euthynnus affinis, Thunnus obesus and Katsuwonus pelamis. However, high yield losses have reduced the value to only Rp. 106,224,971,000. Fishery loss or Post–Harvest Fish loss (PHF) is a decrease in the number of fishery resources that can be consumed, occurring in a marketing distribution chain, regarding of inputs of capture fisheries production, post–harvest handling, processing and marketing (collecting traders, wholesale and retail). The losses caused by the shrinkage of the post–harvest result in capture fishery reach 30–40 % [2]. The resulting losses of catching fisheries include the physical condition of the fish catch, quality and financial losses [3]. One disadvantage can occur at any stage in the supply chain, from catching or harvesting to the consumer [4]. The resulting fisheries post–harvest losses occur in all sequences of fisheries process and are related to the characteristics of fishery products. The series of fisheries activities include preproduction, production, management and marketing carried out in a fishery business system.
At the pre–production stage, the resulting fisheries post–harvest losses associated with the characteristics of fishery products are seasonal. The level of the capture fisheries production, in general, is highly fluctuating, depending on the seasonal pattern. In peak season, supply to fishery products increases, so they are often unabsorbed by the market priced lower by the consumer. It is a typical case of losses incidence at the pre–production stage. At the stage of production to marketing, the characteristics of a perishable fresh fishery product further increase the risk of losses if proper handling is not carried out until the stages of product distribution to the final consumer. Fishery products are also voluminous, so the handling is not easy to implemented.

The above situation underlines the need for handling losses, not to increase the value of the catch but also to improve the supply of fish for the fulfillment of consumption needs and to implement a better management system. As mentioned by New Partnership for Africa’s Development the decrease in losses is closely linked to the management systems and resource wealth generation [3]. The most obvious way to increase fish supply, even without increased landings, is to reduce losses of what is currently caught, it is further that attention should be given to reducing losses [5].

Efforts to decrease or prevent losses do not escape the condition of some factors, which can be categorized as techno-socio-economic factors. With this in mind, the purpose of this research to analyzed these factors. Which affect the shrinkage of capture fisheries, with a focus on three social, which are technical social and economic aspects.

2. Methods
The market for fish is assumed to be perfectly competitive where everyone can participate and the seller is a price taker. Consider a fish value chain player that seeks to maximize profit [6]. The methodological approach used in this research is case study using data taken with survey technique involving selected respondents through random sampling. The respondents represent the group of fishermen (10 respondents), collectors (10 respondents), intermediate traders (10 respondents), processors and consumers (10 respondents), which totals 40 respondents. The questions in the survey were adapted from the Exploratory Fish Loss Assessment Method (EFLAM) approach while data processing was conducted using multiple linear regression.

These methods have been developed and adopted in many countries especially in Africa [7, 8, 9, 10, 11]. (Based on rapid and/or participatory rural appraisal (RRA and/or PRA), EFLAM is planned and performed to generate qualitative and indicative quantitative data [12, 11].

\[ TFL = VPL + LRQL \]

Total Financial loss = Value of physical loss (kg) + loss in revenue due to quality loss (Rp)

Before running the regression analysis, validity and reliability tests were done, resulting in the following. Validity criteria, all factors that were found valid (coefficient value > 0.300) [13]. Meanwhile, based on the Cronbach’s reliability criteria (\( \alpha > 0.6 \)) [14]. It was found that the instrument used in the analysis is reliable (\( \alpha = 0.820 \)). It was found that the selected independent variables were statistically able to explain 72.3 % variation in the dependent variable (fish losses), the rest (27.7 %) belonging to the non-observed independent variables. These selected and thus observed independent variables were: type of fish, fish quality, price, size of fish, shelf life, season and sorting.

3. Results and Discussion

3.1. Descriptive account of factors potentially influencing handling practices and fish losses
The problem of fish losses in Indonesia, including in Palabuhan Ratu was related to the existing natural conditions in the area and its surrounding. Sukabumi District, where Palabuhan Ratu is located, is astronomically located at \( 6°57'–7°07' \) South Latitude and \( 106°22'–106°33' \) East Longitude and is of the influence of tropical climate, with an average temperature of 23.5 °C and precipitation of 2,806 mm. The district, with an area coverage of 412,799.54 ha has a coastline length of approximately 105 km so
that fisheries become a essentials part of the livelihood of people in the region [1]. Nine of 45 sub-districts in Sukabumi District is a coastal sub-district directly facing the Indian Ocean. The sub-districts are Tegalbuleud, Cibitung, Surade, Ciracap, Ciamas, Simpenan, Palabuhan Ratu, Cikakak and Cisolok. Such a high temperature and humidity of tropical climate as well as the fisher’s dependency on the fishery make proper fish handling so challenging.

Fishermen in the coastal sub-districts perform a relatively centralized fish landing, in Palabuhan Ratu Landing Place (Tempat Pendaratan Ikan, TPI). The local fishermen shared roles with those from other provinces in supplying the catch to this Palabuhan Ratu. Local fishermen used boats/fishing vessels, motorboats of 5–30 GT size; on the other hand, fishermen from other provinces engaged capture with regional coverage using relatively larger vessels of 15–60 GT. Fishing equipment that was used were varied, i.e., fishing line, gillnet, chart, payang, longline, purse seine and trammel net. Size-wise, the existing vessels that land fish in Palabuhan Ratu can be categorized into: motorboats sized < 5 GT (58 %), motorboats sized 6–10 GT (8 %), motorboats sized 11–20 GT (3 %), motor boats sized 21–30 GT (4 %), motorboats sized > 30 GT (1 %) and non-engine boats (16 %). Most of the fish landed in Palabuhan Ratu was auctioned in fresh condition. This condition was related to short fishing operation time, i.e., half-day fishing. Longer-trip, which spent more than two days at the sea, catch which were landed by only a few boats, i.e., purse seiners, squid netters and longliners.

From the social factor, the condition that potentially influences the fish loss cases were human resources. In general, educational achievement of market players in Palabuhan Ratu was low. Most fishers, traders, processors and consumers only finished primary school (35 %), followed by junior high school (25 %), high school (25 %) and university (15 %).

Poor technical and social circumstances caused terrible fish handling and processing condition in Palabuhan Ratu. Fish products from processors in Palabuhan Ratu and the surrounding areas were limited to traditional ones. The average processing methods comprised smoking, salting, sun-drying and fermentation. Fisher’s wives and relatives, who predominantly did the processing, sold the processed fish on a weekly basis at a local market and gave the sales revenues to their husband. These included fresh fish (40 %) smoked fish (20 %), salted fish (25 %) and another fish processing (15 %). In the case of handling of fresh fish, only a few of the market players in Palabuhan Ratu applied a cold chain system while others apply inadequate method and equipment. Such a condition results in an insufficient distributional coverage; fish products from Palabuhan Ratu were marketed only to near locations such as Bandung, Bogor, Jakarta and Sukabumi.

Table 1. Summary of fish handling practices and circumstances in Palabuhan Ratu.

| No. | Market player | Activities associated to handling | Economic | Social |
|-----|---------------|----------------------------------|----------|--------|
| 1.  | Fishers       | • Fishing following seasonal pattern, taking whatever available within an average length of trip of respective type of vessel (and gear) | • For selling of the catch at the auction place, while women participate more in creating profit through processing and retailing. | • Networking and communication among fishers, particularly regarding where to catch and where to sell the fish |
|     |               | • Sorting and grading based on species (or species group), size and quality | • Optimizing the capacity of the available fish hold and fishing trip to | • Extending the fishing trip whenever necessary (for particular boat |
|   |   |   |
|---|---|---|
|   | **2. Trader** |   |
|   | • First traders collect auctioned fish and store it in less hygienic and proper equipment with inadequate cooling material | • Fresh and processed products are sold on local markets in the and nearby districts |
|   | • Transporting fish to next market nodes on foot, by bike, motorcycle or mini trucks, depending on the distance. | • Selling prices are based mainly on the type of product and the quality of raw material |
|   |   | • Similar to fishers, traders build effective networking and communication so that collective massive economic losses can be managed |
|   |   | • Most processors link themselves to certain traders or fishers in order to secure supply of good fish with the best prices |
|   | **3. Processors** |   |
|   | • Processors apply simple technologies to meet local markets | • Profit is pursued by target market segmentation |
|   | • Fish of different grades are processed for varied types of product and segmented qualities | • Most local consumers opt to consume more fish when supply is high and easily convert to substitutes when there is a shortage |
|   |   | • Most processors link themselves to certain traders or fishers in order to secure supply of good fish with the best prices |
|   | **4. Consumers** |   |
|   | • Consumers are likely to prefer fresh fish than processed ones | • Most local consumers opt to consume more fish when supply is high and easily convert to substitutes when there is a shortage |
|   |   | • Most processors link themselves to certain traders or fishers in order to secure supply of good fish with the best prices |
3.2. The resulting condition: rate of fish loss

With the condition of factors as described above, it was found that the rate of fish loss in Palabuhan Ratu is high. The high loss rate is contributed by eight species namely frigate tuna (*Euthynnus affinis*), yellowfin tuna (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), white sardinela (*Sardinella*), bigeye hairtail (*Trichiurus lepturus*), marlin, short mackerel (*Rastrelliger faughni*) and squid (*Loligo sp.*).

| No | Fish species                  | Scientific name  | Landing (%) | Next chains (%) |
|----|-------------------------------|------------------|-------------|-----------------|
| 1  | Frigate tuna (*tongkol*)       | *Euthynnus affinis* | 4           | 5               |
| 2  | Yellowfin tuna (*tuna*)        | *Thunnus obesus*  | 3           | 3               |
| 3  | Skipjack                      | *Katsuwonus pelamis* | 4           | 5               |
| 4  | White sardinela (*tembang*)   | *Sardinella*     | 4           | 6               |
| 5  | Bigeye hairtail (*layur*)     | *Trichiurus lepturus* | 4           | 5               |
| 6  | Makaira (*marlin*)            | *Istiohoridae*    | 5           | 5               |
| 7  | Short mackerel (*kembung*)    | *Rastrelliger faughni* | 5           | 6               |
| 8  | Squid                         | *Loligo sp.*      | 5           | 6               |

| Fish loss average (%) | 4.25 | 5.12 |

Table 2 showed that the fish catch landed in Palabuhan Ratu lost its amount since the first node of the chain approximately 4.25% while in the next chain it amounts to 5.12%. It was comprised physical and value losses. By the time the catch was landed at the port and went to the auction place, a number types of damage can be spotted which ranged from few scratches, fragmentation to total impairment. Some discarded directly as wastes while others were sorted based on (group of) species, size and quality and then priced accordingly.

In the next nodes of the chain, losses occurrence attributed to several types of mishandling including processing without proper chilling and or inefficiency in handling and processing steps. During processing, traditional techniques such as meatball and fish floss making, the fish loss were accounted for discarding non-process portion. It is worth noting here. However, those processing activities using such traditional technologies can generate value-added up to 1.25%.

3.3. Statistical analysis

Simultaneously, these variables selected for the regression were found influencing the level of fish losses with a confidence level of 95% (Fcalc 4.25). Table 3 shows the results of partial analysis of the variables.
Table 3. Result of regression analysis.

| Variable          | Parameter estimate | Significance |
|-------------------|--------------------|--------------|
| Species of fish   | 2.11               | S            |
| Quality of fish   | 2.31               | S            |
| Price of fish     | 1.75               | S            |
| Size of fish      | 2.14               | S            |
| Shelf life of fish| 2.10               | S            |
| Season            | 2.01               | S            |
| Sortation         | 1.73               | NS           |

Referring to this statistical result and considering the observed chronological sequence of this variables (factors), the relationships among these factors and their effect on losses can be depicted as in figure 1. In general, this figure suggests that there are some factors like season, where interventions are impossible and some others which partially or simultaneously can be intervened for the best expected output, which in this context is the level of losses.

3.4. Synthesis of the result

To get the best quality and to minimize losses, actually there is a standard called HACCP (Hazard Analysis Critical Control Point), that should have been applied in all stages in the handling and processing in Palabuhan Ratu. This standard equips managers with scientific, rational and systematic reference to identify, control and monitor fish processing activities such that fish quality can be maintained. However, field observation which has been presented showed that technical, economic and social environment did not allow such a standard to perform well. As described, fish landed in the auction place of Palabuhan Ratu are caught using various types of fishing vessels that operate various types of gear and exercise different lengths of the trip and this brings consequences that implicate technical difficulties in fish handling. As it was noted during the research, fish quality has a broad range of quality disparity. Moreover, these fish belong to many owners (fishers) such that immediate collective handling is very difficult. The difficulties are capitalized as these fishers have a somewhat limited awareness of the need for proper handling of their catch. Low educational achievement undoubtedly contributes to an unfavorable social condition. As shown in table 1, only a few fishers apply cold chain system. While
cold storage facility was also limited. This social factor simply complicates efforts to maintain the good quality of fish and to minimize losses. The social and technical problems could be solved if significant economic incentives were accruing from practicing proper handling and processing. However, the existing economic circumstances also could not support the necessary incentives. Processors, for example, considered the revenue margin which implements better handling and or processing would not be significant.

All of these problems represents cyclical chains, where each factor had interactions to influence one another. Given this, interventions become relevant. The options of interventions may be based on the result of the following statistical analysis. Factors listed in the results of the statistical analysis (table 1) can be grouped into external ones, where control is not possible and internal ones, to which interventions can be considered. The statistical regression (table 1) shows that among the technical factors, the most influential ones were (i) handling of landed fish, (ii) fish sortation, (iii) fish size, (iv) fish shelf life and (v) season; among economic aspect, factors with the most significant influence were (i) fish price fluctuation and (ii) price level; meanwhile, among the social factors, those that had the most significant influence was the revenue distribution system.

In line with the results of field observation presented earlier, it was identified that interventions to internal factors in brief can be described as facilities that will enable market players to exercise efforts aiming at saving the value of fish. Based on this, a relevant policy implication of this research is needed for effective programs which cover: (i) development of cold chain facilities and infrastructure, (ii) development of distribution facilities and infrastructure and (iii) improvement in skills and knowledge of fish derivative product processors.

4. Conclusion
This research found that the case of fish losses in Palabuhan Ratu was relatively high. The case involves some factors/variables which are interdependent one to another, a situation that justifies interventions. The interventions are those that can enable market players to exercise efforts aiming at saving the value of fish. In general, the interventions, which comprise technical, social and economic types should be targeted directly to most influential variables as can be deduced from both the detailed presentation and the statistical analysis carried out in this research.

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