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Modeling Optimal Income and Job Increase on Fishing in the Current Economic Scenario in Angola Until 2050

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Abstract: In this paper, forecasts were made and two-stage deterministic optimization models were designed to maximize annual fish sales revenues and increase the number of jobs on fishing in Angola in the current scenario. Starting from historical data from 2016 to 2022, taking their means and standard deviations, normal distributions were generated up to 2050. If these models were adopted, annual income would reach Kz 260,753,942,425.00 as opposed to the current Kz 246,617,594,646.47 produced with the sale of 5 species of crustaceans, 3 of mollusks, 34 of demersal fishes, 6 of pelagic fishes and 5 of freshwater fishing, resulting in an annual increase in income of around 5.73% and 6,514 new jobs and direct self-employment, of which 328 in industrial fishing, 319 in semi-industrial fishing, 3,355 in maritime artisanal fishing and 2,512 in freshwater artisanal fishing. Of these, 5,071 will be for fishermen and 1,443 for women fish processors. The optimal portfolio of fish sales revenue would be 3% for crustaceans, 1% for mollusks, 34% for demersal Fishes, 54% for pelagic fishes and 8% for fish from freshwater fishing. These results would be excellent for the fishing sector to contribute to achieving the employability goals envisaged by the Angolan government in the medium and long term.

Keywords: Forecasting, Two-Stage Deterministic Optimization Models, Fish Sales Income, Jobs and Self-Employment in Fishing

1. Introduction

Angola is a country located in Southern Africa, rich mainly in forestry, oil, natural gas, water and marine resources, and is also becoming a very important location for the fishing business currently observed in its various lakes and around along its extensive coastline that crosses the provinces of Bengo, Benguela, Cabinda, Cuanza Sul, Luanda, Namibe and Zaire, sharing the Atlantic Ocean with the Democratic Republic of Congo and the Republic of Congo. Even so, unemployment has been affecting many families in the country, a situation that occurred many years ago in Germany, Canada, New Zealand, Holland, Portugal and Sweden, as stated [1].

Modeling and optimization algorithms, linear optimization with focus in Deterministic Operations Research and simulation, are widely used in problem solving in many fields of research as stated by [2, 3]. In this article these tools are applied to forecast tons of fish catches, demand and prices, and optimize sales revenue ideally for a long term horizon to allow decision makers to manage the increase in jobs.

Uncertainty in fish catches, caused by death, migrations or variation in the frequency of rainfall during the rainy season (September to May) and the level of pollution in the sea from oil exploration activity, have conditioned income from the sale of fish and indirectly the increase of jobs in fisheries in Angola.

In this order of ideas, what mathematical models can be used to optimize fish sales income and significantly increase fishing jobs in the current economic scenario in Angola until 2050?

The paper aims to develop a strategy based on mathematical models to optimize fish sales income and significantly increase fishing jobs in the current economic scenario in Angola until 2050.

The paper consists of the following 7 subtopics: 1. Introduction, 2. Theoretical background, 3. Methodology, 4. Catch, demand and price forecasting, 5. Sales optimization models, 6. Results, new jobs generation and discussion, and 7. Conclusion.

2. Theoretical Background

2.1. Basic Concepts

For the development of the research we assumed and clarified some key basic concepts as well as the schematic representation of the strategy in sections 2.1 and 2.2.

Artisanal fishing: it is a type of fishing done with family labor, with small boats, such as canoes or rafts, or even without boats, whose area of activity is close to the sea coast, in rivers and lakes [4].

Sea fishing: it is a type of fishing carried out directly by the Ministry of Fisheries by companies and supervised by the government, with modern medium and large vessels, whose area of operation is in the seas, relatively far from the coast [4].

Freshwater fishing: it is a type of fishing carried out by family labor, associations and companies, supervised by the government, carried out with small vessels, whose area of operation is in small or large and deep rivers or lakes [4], in all waters that are part of the national hydrological cycle not included in inland waters [5]. In Angola it is regulated by Law Number 6/02, of 21 June [6].

Employment: form of professional activity, in which the individual has a formal, long-term employment relationship with a single employer, maintaining a type of relationship with organizations generally based on the logic of providing services [7].

Self-employment: form of autonomous professional activity, in which the individual does not have a formal, long-term employment relationship with a single employer, not maintaining a type of relationship with organizations based on the logic of providing services [7].

Forecasting models: is a mathematical expression that represents the functional relationship between dependent and independent variables, obtained by estimating their parameters, incorporating the behavior and characteristics of their historical values (occurring observations), with the lowest possible margin of error, and which serves to predict future or unknown behavior and values. These models can be: 1) Linear or non-linear regression models (single or multiple) [8], 2) exponential smoothing or smoothing, 3) Autoregressive AR(p), 4) Moving Averages MA (q), 5) Autoregressive Moving Averages ARMA (p, q), 6) Autoregressive Integrated Moving Averages ARIMA (p, d, q) [9-11], 7) Generalized Autoregressive with Conditional Variance (GARCH), 8) Dynamic models (linear or non-linear) and among others. (p) is the Autoregressive order, (d) is the number of times the series must be differentiated for it to be stationary and (q) is the Moving Average order [11, 12]. The prediction can also be obtained by means of algorithms or simulation of values knowing the distribution to which it is intended to adjust the values to be generated and the distribution parameters such as mean and standard deviation [12-14].

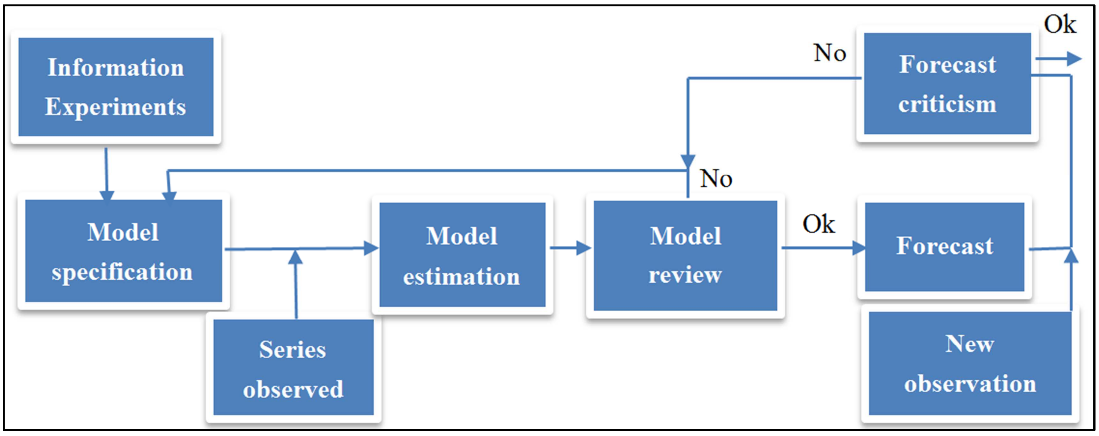

Figure 1. *Box Jeanks script for model determination and forecasting.*

Linear optimization model with constraints: Let $x_1, x_2, \dots, x_n$ decision variables, $c_1, c_2, \dots, c_n$; $a_{11}, a_{12}, \dots, a_{1n}$; $a_{21}, a_{22}, \dots, a_{2n}$; … ; $a_{m1}, a_{m2}, \dots, a_{mn}$; $b_1, b_2, \dots, b_m$ decision parameters, a problem is called a linear programming or linear optimization model with constraints on every expression of standard form:

$$\text{Max (or Min) } z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Subject to:

$$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n = b_2$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n = b_m$$

$$x_j \geq 0$$

Where:

Presence of decision variables, x_i, i =1,2,…,n;

Presence of decision parameters, c_i, a_{ij} e b_j, with j = 1,2..., m;

The linear objective function z to be optimized;

Linear constraints, where the sign "=" can be replaced by" $\geq$ " or " $\leq$ " depending on the situation;

The non-negativity ($x_j \geq 0$) of the decision variables [15].

2.2. Employment Growth Strategy

The strategy to be developed for determining the optimal revenue and generating the number of jobs in fishing in Angola by 2050 is illustrated in Figure 2.

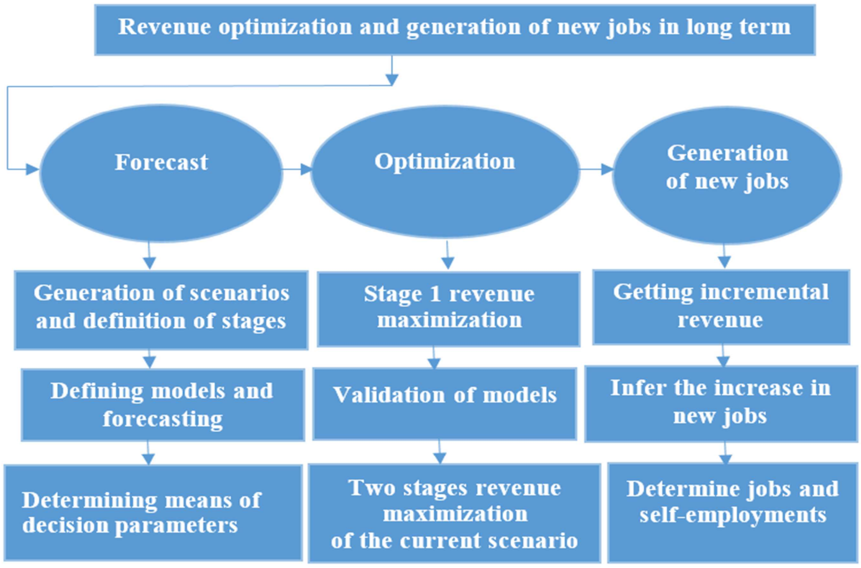

Figure 2. *Strategy for determining the optimal revenue and generating new jobs.*

2.3. Presentation of the Research Field

2.3.1. Catches, Demand, Income and Employment

In Angola, in addition to the Ministry of Fisheries which controls maritime fishing (official), there are artisanal fishermen who carry out freshwater fishing (in rivers and lakes), although they also fish in the sea along the coast that most of them do not pay taxes to the state. This is a rapidly developing subsector that brings together countless families, thus contributing to the diversification of the national economy with a significant impact on achieving the strategic objectives of the Angolan government, which aim not only at food safety, but fundamentally at combating hunger, the reduction of poverty and the improvement of the social conditions of the populations. Annual catches in the period (2016-2022) were close to 425,708 tons per year, with 15,478 for inland fishing and 410,230 for sea fishing [16-18].

Sea fishing comprises 53 species and 4 categories of fish, namely 5 species of Crustaceans, 3 of Mollusks, 34 of Demersal fish, 6 of Pelagic fish and 5 of freshwater fishing, as specified below:

Crustaceans: Striped grunt, Shrimp, Crab, Coastal Shrimp, and Lobster.

Mollusks: Cuttlefish, Squid, and Octopus.

Demersal fish: Needlefish, Anchovy, Codfish, Catfish, Bolo fish, Bearded goby, Parrotfish, Violet blenny, Bullnose ray, Scrawled filefish, Croaker, Dentex, Dorado, Grouper, Flounder, Shorthead scorpionfish, Black scalyfin, Sand whiting, Sand steenbras, Kelpfish, Red snapper, Hake, Blackgoby, Bluefish, Skate, Drumfish, John Dory, Flying gurnard, Skipjack tuna, Chub mackerel, Calico grouper, Blenniidae sp., Shark, Other species.

Pelagic fish: Mackerels, Tuna, Swordfish, John Dory, Sardines, and Other species.

Fish from freshwater fishing: Catfish, Rastrineobola (a river fish found in Cabinda/Angola), Mullet, Turkey fish, and Other species.

In the yearbooks of the Ministry of Fisheries [16-18], historical data from 2016 to 2022 revealed that demand is situated at 85% of fish catches, as can be seen in Figure 3.

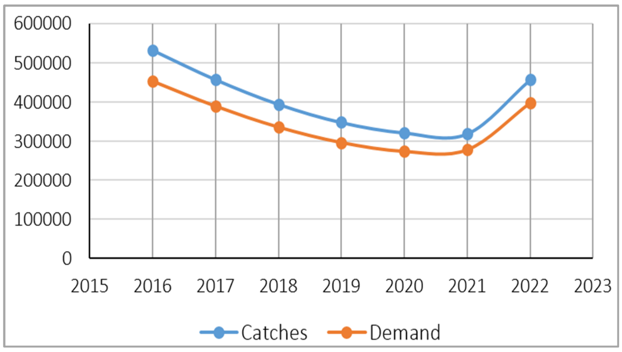

Figure 3. *Catches and demand of fish in Angola from 2016 to 2022.*

As for catch, Crustaceans are distributed up to 41% for Striped grunt, 11% for Shrimp, 32% for Crab, 14% for Coastal Shrimp and 3% for Lobster. Mollusks, up to 33% are cuttlefish, 47% are Squid and 20% are Octopus. Of the Demersal fish, up to 0.8% is Needlefish, 1.1% is Anchovy, 1.7% is Codfish, 1% is Catfish, 1% is Bolo fish, 1.4% is Bearded goby, 0.9% is Parrotfish, 17.4% is Violet blenny, 7.7% is Bullnose ray, 0.1% is Scrawled filefish, 3.5% is Croaker, 1.9% is Dentex, 0.9% is Dorado, 0.4% is Grouper, 1.2% is Flounder, 0.5% is Shorthead scorpion fish, 1.7% is Black scalyfin, 8.8% is Sand whiting, 0.5% is Sand steenbras, 0.7% is Kelpfish, 1% is Red snapper, 12.8% is Hake, 1.5% is Blackgoby, 2.4% is Bluefish, 0.9% is Skate, 1.4% is Drumfish, 0.3% is John Dory, 0.1% is

Flying gurnard, 1% is Skipjack tuna, 1.4% is Chub mackerel, 3.7 is Calico grouper, 2.5% is Blenniidae sp, 0.2% is Shark and 17.6% is Other demersal species. For pelagic fish, up to 23.6% is Mackerels, 9.8% is Tuna, 7.2% is Swordfish, 2.5% is Rooster, 54.3% is Sardines and 2.5% is Other Pelagic Species. As for fish from freshwater fishing, up to 52% is Catfish, 32% is Rastrineobola (a river fish found in Cabinda/Angola), 11% is Mullet, 3% is Turkey fish and 1% corresponds to other freshwater fishing species [16-18].

Until 2022, annual sales were around 246,617,594,646.47 Kwanzas, providing 88,252 self-employment to fishermen and 25,116 jobs to women fish processors. Fishermen are distributed in 3,651 in Industrial fishing, 1,173 in Semi-industrial fishing, 47,926 in maritime artisanal fishing and 35,502 in freshwater artisanal fishing. Fish processors were 2,057 in Industrial fisheries, 4, 379 in Semi-industrial fisheries, 10,460 in maritime artisanal fisheries and 8,219 in freshwater artisanal fisheries [16-18].

2.3.2. Fish Catching Scenarios

The sources of uncertainty regarding catches are water pollution and rain that transport food waste to the seas, rivers and lakes, causing an increase or decrease in the amount of fish in each rainy year in as quoted by [5, 6] confirmed by the data observed in [16-18]. Thus, the following scenarios have occurred with some notoriety:

1. Pessimistic scenario: Characterized by considerable reduction in catches due to low rainfall, low reproduction, shortage of food for fish in the seas, rivers and lakes, the migration of fish from the sea to the seas of neighboring countries, the death of some fish due to pollution of marine waters by spills resulting from the exploitation of hydrocarbons.
2. Current scenario: Characterized by the relative abundance of catches due to the occurrence of moderate rainfall, and relative reproduction, existence of food for fish in the seas, rivers and lakes, little migration of fish from the sea to the seas of neighboring countries, little death of some fish due to the reduction of marine waters pollution by spills resulting from the exploitation of hydrocarbons.
3. Optimistic scenario: Characterized by abundant catches due to heavy rainfall, high reproduction, abundance of food for fish in seas, rivers and lakes, to the Angolan seas, and residual levels of marine water pollution.

2.3.3. Prices

A little across the country there are no infrastructures for conservation and proper processing of fish. A large majority of the population turns to artisanal fishermen to purchase fish. This reality means that there is no significant variability in the prices charged by fishermen, as they want to get rid of perishable fish. Also, it is not government practice to change prices in the short or medium term. Until 2022, the annual national prices for the sale of 1 kg of fish in Kwanzas were: 1,835 for Striped grunt, 1,194 for Shrimp, 1,059 for Crab, 3,860 for Coastal Shrimp, 2,405 for Lobster, 1,093 for Cuttlefish, 999 for Squid, 1,018 for Octopus, 883 for Needlefish, 652 for Anchovy, 795 for Codfish, 448 for Catfish, 517 for Bolo fish, 695 for Bearded goby, 755 for Parrotfish, 803 for Violet blenny, 614 for Bullnose ray, 592 for Scrawled filefish, 1,229 for Croaker, 1,005 for Dentex, 655 for Dorado, 2,130 for Grouper, 1,114 for Flounder, 998 for Shorthead scorpionfish, 635 for Black scalyfin, 366 for Sand whiting, 741 for Sand steenbras, 456 for Kelpfish, 1,271 for Red snapper, 993 for Hake, 562 for Blackgoby, 1,377 for Bluefish, 328 for Skate, 888 for Drumfish, 667 for John Dory, 578 for Flying gurnard, 926 for Skipjack tuna, 285 for Chub mackerel, 646 for Calico grouper, 489 for Blenniidae sp, 628 for Shark and 294 for other demersal species, 640.4 for Mackerels, 334.7 for Tuna, 419 for Swordfish, 732.3 for Rooster, 404.7 for Sardines, 376 for other pelagic Species, 448 for Catfish, 1,229 for Rastrineobola, 285 for Mullet, 328 for Turkey fish and 888 for other mainland fishery species [16-18].

3. Methodology

A wide range of literature was used, with emphasis on Yearbooks of the Ministry of Fisheries and the Sea of the Republic of Angola for the period 2016-2022, in order to understand the annual historical reality, especially in data on catches, demand and prices for fish, structure of the sector, agents involved, recipes and scenarios. The collected data and information were used to generate time series for the 2023-2050 sub period through normal distributions, knowing the mean and standard deviation of historical data on catches, demands and prices, after confirming the normality of the data using the Shapiro-Wilk test, and determine the means of the annual forecasts with the aid of the R software. Several Autoregressive Integrated Moving Averages (ARIMA) models were also generated and we opted for the generation of normal distributions because we produced white noise residuals of lesser magnitude taking to account of few data (7 years) and not short term data as illustrated in [8-14]. The period 2016 - 2050 on which the study was based was divided into two sub periods, with 2016-2022 considered the first stage and 2023-2050 the second stage. The values (parameters) in the scenarios were estimated, with a certain standard deviation σ in the intervals $[x_t - 2\sigma; x_t + 2\sigma]$, where the series $L = \{x_t - 2\sigma\}_{t=1,\dots,n}$ went to pessimistic scenario values, $\{x_t\}_{t=1,\dots,n}$ for the current scenario and $U = \{x_t + 2\sigma\}_{t=1,\dots,n}$ for the optimist.

First-stage (2016-2022) and two-stage (2016-2022) and (2023-2050) deterministic optimization models were created as applied in [2, 15, 19]. This study only analyzed the current scenario in Angola in the fisheries sector, taking as parameters the means of the time series $\{x_t\}_{t=1,\dots,n}$. Income from fish sales was maximized and then incremental income was used to determine the increase in jobs for fish processors and self-employment for fishermen, using the direct proportionality calculation. The optimization models were solved using the CPLEX optimization Software. The respective sales revenue optimization models were validated in the first stage, taking data of 2018 or 2019 as references, for each of the 5 categories of fish.

4. Demand, Catches and Prices Forecast

In this section, with the help of Software R, and in accordance with [8-14], it is illustrated how the predictions and the means of the prediction values were obtained, which represent each of the parameters in each scenario.

4.1. Crustaceans Demand Forecasting with R

Script R

```
> library(read.xls)
>x <-read.xls("Crustacians.xls")
> shapiro.test(x)
Shapiro-Wilk normality test
data: x
W = 0.95627, p-value = 0.7862
> year<-2016:2022
>plot(year, x,type="line",main="Demand of Crustacians",xlab="year",ylab="Tons",col="black",ylim=c(2983, 4467))
```

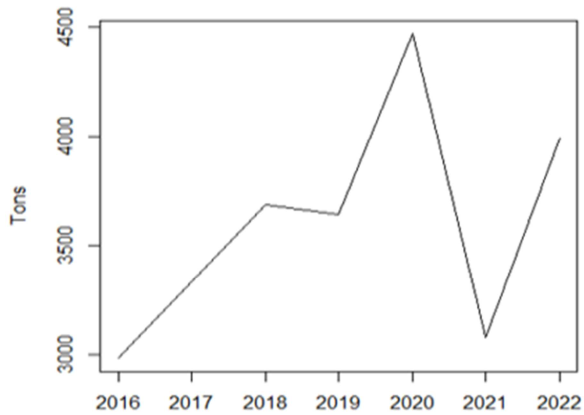

Figure 4. *Crustacians demand ploting in the first stage.*

```
> acf(x)
> pacf(x)
```

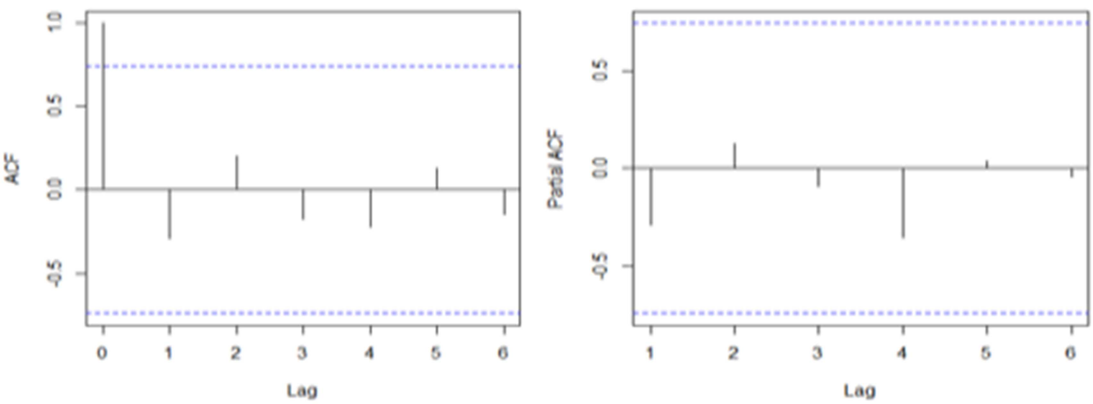

Figure 5. *Correlograms of Crustacians demand ploting in the first stage.*

```
> summary(x)
Min. 1st Qu. Median Mean 3rd Qu. Max.
2983 3208 3642 3598 3838 4467
> simulData=rnorm(n=35,mean=mean(x),sd=sd(x))
> simulData
[1] 3569.314 3301.288 3114.084 3005.155 4074.677 3083.253 3946.066 4331.730
[9] 4201.899 3525.375 3316.360 3034.815 3588.090 3476.398 3679.329 3282.606
[17] 3926.003 3970.426 4159.168 4771.687 3701.034 3297.459 3557.430 2748.335
[25] 3665.569 3375.662 3809.631 3457.512 2877.185 3616.865 2891.660 4065.829
```

[33] 2643.225 3523.745 3836.748
> hist(simulData)

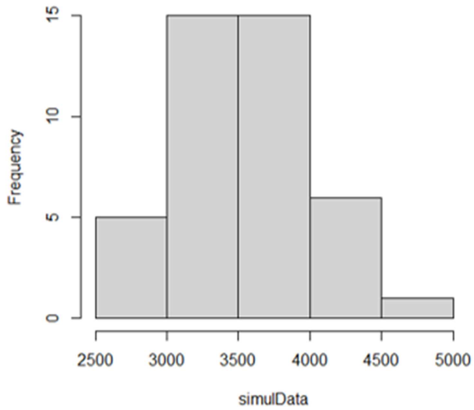

Figure 6. *Histogram of Crustacians demand in the second stage.*

> boxplot(x,simulData)

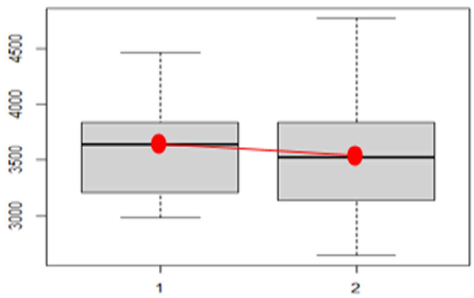

Figure 7. *Variability ploting by Box-plot of Crustacians demand in the first and in the second stages.*

> summary(simulData)
Min. 1st Qu. Median Mean 3rd Qu. Max.
2643 3173 3525 3528 3830 4772
> L=simulData-2*sd(x)
> mean(simulData-2*sd(x))
[1] 2484.737
> U=simulData+2*sd(x))
> mean(simulData+2*sd(x))
[1] 4571.916
> year<-2016:2050
>plot(year,x,simulData,L,U,type="line",main="Demand of Crustacians",xlab="year",ylab="Tons",col=c("black","red","blue"),ylim=c(1543.4, 5672))

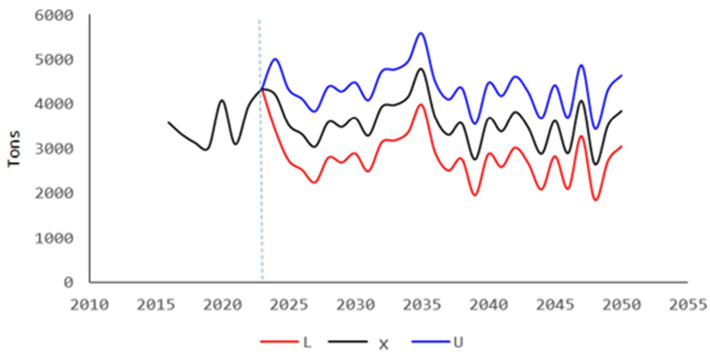

Figure 8. *Scenarios ploting of Crustacians demand from 2016 to 2050.*

By this procedure were obtained the Table 1, Table 2 and the price forecast parameters.

Table 1. *Annual fish demand, in tons, from 2016 to 2022 and forecasts from 2023 to 2050.*

#	Fish categories	First stage (2016-2022)		Expected values at the second stage (2023-2050)		
		Mean	Standard-Deviation	Pessimistic scenario (L)	Current scenario (x)	Optimistic scenario (U)
1	Crustaceans	3622.8	549.8	2459.4	3559	4658.8
2	Mollusks	2127	846.57	322	2015	3708
3	Demersal fish	78140.6	52024.2	52071	82311	186359.8
4	Pelagic fish	249327	20183	206275	246641	287007
5	Freshwater fishing	15478	5873.2	3302	15048	26794

With the exception of demersal fish, the current scenario will register a reduction in demand in the second stage, as can be seen in the example shown in the Figure 7, which may imply a reduction in income if price behavior continues. The series of these parameters showed normal distributions according to the Shapiro-Wilk test for less than 50 observations and white noise residuals, shown in the Figure 5, according to the schedules (Simple Autocorrelation and Partial Autocorrelation functions) as mentioned by [12, 13], sufficient reasons that led to the generation of forecasts through simulation or adjustment to the normal curve knowing the means and standard deviations of the first stage.

4.2. Prices Forecast

There are no different scenarios from the current one in relation to fish prices in Angola, except for updates arising from the inflation rate. Similarly, the price series also showed normal distributions and white noise residuals, so the criterion for generating forecasts was also the simulation of a normal distribution, knowing the means and standard deviations of the first stage. Thus, from 2023 to 2050, the following annual national prices were forecasted for each Kg of fish in Kwanzas: 1,812 for Striped grunt, 1,164 for Shrimp, 1,031 for Crab, 3,978 for Coastal Shrimp, 2,374 for Lobster, 1,074 for Cuttlefish, 975.7 for Squid, 1,006 for Octopus, 846 for Needlefish, 660 for Anchovy, 779 for Codfish, 438 for Catfish, 504 for Bolo fish, 707 for Bearded goby, 749 for Parrotfish, 777 for Violet blenny, 584 for Bullnose ray, 582 for Scrawled filefish, 1,235 for Croaker, 1,031 for Dentex, 676 for Dorado, 2,101 for Grouper, 1,078 for Flounder, 1,024 for Shorthead scorpionfish, 629 for Black scalyfin, 355 for Sand whiting, 725 for Sand steenbras, 451 for Kelpfish, 1,273 for Red snapper, 1,007 for Hake, 568 for Blackgoby, 1,404 for Bluefish, 346 for Skate, 863 for Drumfish, 746 for John Dory, 577 for Flying gurnard, 944 for Skipjack tuna, 275 for Chub mackerel, 624 for Calico grouper, 502 for Blenniidae sp, 619 for Shark and 287 for other demersal species, 626.3 for Mackerels, 339.5 for Tuna, 412 for Swordfish, 699.8 for Rooster, 389.6 for Sardines, 366 for other pelagic Species, 438 for river Catfish, 1,235 for Rastrineobola, 275 for Mullet, 346 for Turkey fish and 863 for other freshwater fishing species.

4.3. Catches Forecast

Catches forecast resulted the values shown in the Table 2.

Table 2. *Annual fish Catch, in tons, from 2016 to 2022 and forecasts from 2023 to 2050.*

#	Fish categories	First stage (2016-2022)	Expected values at the second stage (2023-2050)		
		Means	Pessimistic scenario (L)	Current scenario (x)	Optimistic scenario (U)
1	Crustaceans	4166.22	2828.31	4 093	5357.62
2	Mollusks	2446.1	370.3	2317	4264.2
3	Demersal fish	89862.2	59881.65	94658	214313.8
4	Pelagic fish	286726.1	237216.3	283637	330058.1
5	Freshwater fishing	17799.7	3797.3	17305	30813.1

5. Fish Sales Optimization Models

For each category of fish, an optimization model was built that maximizes sales income both in the first and in the second stage like in [19] taking into account the demand satisfaction constraints and availability or catches and the respective prices.

5.1. Deterministic Optimization Models in the First Stage

The algebraic representation of each category and type of fish was denoted as follows:

Crustaceans: x_i , $i = 1, 2, 3, 4, 5$; Mollusks: x_j , $j = 6, 7, 8$; Demersal fish: x_k , $k = 9, 10, \dots, 42$; Pelagic fish: x_l, $l = 43, 44, \dots, 48$; Freshwater fishing: y_m, $m = 1, 2, \dots, 5$.

For the first stage (2016-2022) the following deterministic optimization models were built:

a) Crustaceans fish selling model

$Max\ s(x) = 10^3(1835x_1 + 1194x_2 + 1059x_3 + 3860x_4 + 2405x_5)$

Subject to:

$3622.8 \leq x_1 + x_2 + x_3 + x_4 + x_5 \leq 4166.22$

$x_2 + x_3 + x_4 + x_5 \geq 1.44x_1$

$x_1+x_3+x_4+x_5\geq 8.1x_2$

$x_1+x_2+x_4+x_5\geq 2.13x_3$

$x_1+x_2+x_3+x_5\geq 6.14x_4$

$x_1+x_2+x_3+x_4\geq 32.3x_5$

$x_1\geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0, x_5\geq 0$

b) Mollusks selling model

$Max\ s(x)= 10^3(1093x_6+999x_7+1018x_8)$

Subject to:

$2127 \leq x_6+x_7+x_8 \leq 2446.1$

$x_7+x_8\geq 2x_6$

$x_6+x_8\geq 1.13x_7$

$x_6+x_7\geq 4x_8$

$$x_6 \geq 0, x_7 \geq 0, x_8 \geq 0$$

c) Demersal fish selling model

$Max\ s(x)= 10^3(883x_9+652x_{10}+795x_{11}+448x_{12}+517x_{13}+695x_{14}+755x_{15}+803x_{16}+614x_{17}+592x_{18}+1229x_{19}+1005x_{20}+655x_{21}+2130x_{22}+1114x_{23}+998x_{24}+635x_{25}+366x_{26}+741x_{27}+456x_{28}+1271x_{29}+993x_{30}+562x_{31}+1377x_{32}+328x_{33}+888x_{34}+667x_{35}+578x_{36}+926x_{37}+285x_{38}+646x_{39}+489x_{40}+628x_{41}+294x_{42})$

Subject to:

$78141\leq x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\leq 89862.2$

$x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 124x_9$

$x_9+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 89.9x_{10}$

$x_9+x_{10}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 57.8x_{11}$

$x_9+x_{10}+x_{11}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{12}$

$x_9+x_{10}+x_{11}+x_{12}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{13}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 70.4x_{14}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 110.4x_{15}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 4.75x_{16}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 11.99x_{17}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 999x_{18}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 27.6x_{19}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 51.6x_{20}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 110x_{21}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 249x_{22}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 82.2x_{23}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 199x_{24}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 57.8x_{25}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 10.4x_{26}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+$

$x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 199x_{27}$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 141.9x_{28}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{29}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 6.8x_{30}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 65.7x_{31}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 40.7x_{32}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 110x_{33}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 70.4x_{34}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 332.3x_{35}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 999x_{36}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{37}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{39}+x_{40}+x_{41}+x_{42}\geq 70.4x_{38}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{40}+x_{41}+x_{42}\geq 26x_{39}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{41}+x_{42}\geq 39x_{40}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{42}\geq 499x_{41}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}\geq 4.6x_{42}$$

$x_9 \geq 0, x_{10}\geq 0, x_{11} \geq 0, x_{12}\geq 0, x_{13}\geq 0, x_{14}\geq 0, x_{15}\geq 0, x_{16}\geq 0, x_{17}\geq 0, x_{18}\geq 0, x_{19}\geq 0, x_{20}\geq 0, x_{21}\geq 0, x_{22}\geq 0, x_{23}\geq 0, x_{24}\geq 0, x_{25}\geq 0, x_{26}\geq 0, x_{27}\geq 0, x_{28}\geq 0, x_{29}\geq 0, x_{30}\geq 0, x_{31}\geq 0, x_{32} \geq 0, x_{33} \geq 0, x_{34} \geq 0, x_{35}\geq 0, x_{36}\geq 0, x_{37}\geq 0, x_{38}\geq 0, x_{39}\geq 0, x_{40}\geq 0, x_{41}\geq 0, x_{42}\geq 0$

d) Pelagic fish sales model

$Max\ s(x)$=1000 ($640.4x_{43}+334.7x_{44}+419x_{45}+732.3x_{46}+404.7x_{47}+376x_{48}$)

Subject to:

$249327 \leq x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{48} \leq 286726.1$

$x_{44}+x_{45}+x_{46}+x_{47}+x_{48}\geq 2\ x_{43}$

$x_{43}+x_{45}+x_{46}+x_{47}+x_{48}\geq 9.2\ x_{44}$

$x_{43}+x_{44}+x_{46}+x_{47}+x_{48}\geq 12.9\ x_{45}$

$x_{43}+x_{44}+x_{45}+x_{47}+x_{48}\geq 39\ x_{46}$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{48} \geq 0.84\ x_{47}$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{47}\geq 39\ x_{48}$

$x_{43} \geq 0, x_{44} \geq 0,\ x_{45} \geq 0, x_{46} \geq 0, x_{47} \geq 0, x_{48}\geq 0$

e) Fish from freshwater fishing sales model

$Max\ s(y)= 10^3(448y_1+1229y_2+285y_3+328y_4+888y_5)$

Subject to:

$15478 \leq\ y_1+y_2+y_3+y_4+y_5\leq 17799.7$

$y_2+y_3+y_4+y_5\geq 0.92y_1$

$y_1+y_3+y_4+y_5\geq 2y_2$

$y_1+y_2+y_4+y_5\geq 8y_3$

$y_1+y_2+y_3+y_5\geq 99y_4$

$y_1+y_2+y_3+y_4\geq 32.3y_5$

$y_1\geq 0, y_2\geq 0, y_3\geq 0, y_4\geq 0, y_5\geq 0$

5.2. Two-Stage Deterministic Optimization Models

Regarding demand, 3 scenarios were predicted for the second period (2023-2050). The present study only analyzes the current scenario. Two-stage deterministic models integrate first- and second-stage variables. Due to the probable decrease in catches and in demand in the second stage, we consider its variables as real, which can be negative or positive, with only those in the first stage being non-negative. Thus, the second stage variables were denoted as follows for the current scenario:

Crustaceans: $x_i^2, i = 1,2,3,4,5$; Mollusks: $x_j^2, j = 6,7,8$; Demersal fish: $x_k^2, k = 9,10,\dots,42$; Pelagic fish: x_l^2, $l = 43,44,\dots,48$; Freshwater fishing: $y_m^2, m = 1,2,\dots,5$.

Therefore, the two-stage deterministic optimization models in the current scenario are written as follows:

a) For crustaceans

$Max\ s(x) = 1000(1835x_1+1194x_2+1059x_3+3860x_4+2405x_5 +1812x_1^2 +1164x_2^2 +1031x_3^2 +3978x_4^2 +2374x_5^2)$

Subject to:

$3622.8 \le x_1+x_2+x_3+x_4+x_5 \le 4166.22$

$3559 \le x_1+x_2+x_3+x_4+x_5 + x_1^2 + x_2^2 + x_3^2 + x_4^2 + x_5^2 \le 4093$

$x_2+x_3+x_4+x_5 \ge 1.44x_1$

$x_2+x_3+x_4+x_5 + x_2^2 + x_3^2 + x_4^2 \ge 1.44x_1 + 1.44x_1^2$

$x_1+x_3+x_4 \ge 8.1x_2$

$x_1+x_3+x_4+x_5 + x_1^2 + x_3^2 + x_4^2 + x_5^2 \ge 8.1x_2 + 8.1x_2^2$

$x_1+x_2+x_4+x_5 \ge 2.13x_3$

$x_1+x_2+x_4+x_5 + x_1^2 + x_2^2 + x_4^2 + x_5^2 \ge 2.13x_3 + 2.13x_3^2$

$x_1+x_2+x_3 \ge 6.14x_4$

$x_1+x_2+x_3+x_5 + x_1^2 + x_2^2 + x_3^2 + x_5^2 \ge 6.14x_4 + 6.1x_4^2$

$x_1+x_2+x_3+x_4 \ge 32.3x_5$

$x_1+x_2+x_3+x_4 + x_1^2 + x_2^2 + x_3^2 + x_4^2 \ge 32.3x_5 + 32.3x_5^2$

$x_1 \ge 0, x_2 \ge 0, x_3 \ge 0, x_4 \ge 0, x_5 \ge 0, x_1^2 \ge 0, x_2^2 \ge 0, x_3^2 \ge 0, x_4^2 \ge 0, x_5^2 \ge 0$

b) For Mollusks

$Max\ s(x) = 10^3(1093x_6+999x_7+1018x_8 +1074x_6^2 +975.7x_7^2 +1006x_8^2)$

Subject to:

$2127 \le x_6+x_7+x_8 \le 2446.1$

$2015 \le x_6+x_7+x_8 + x_6^2 + x_7^2 + x_8^2 \le 2317$

$x_7+x_8 \ge 2x_6$

$x_7+x_8 + x_7^2 + x_8^2 \ge 2x_6 + 2x_6^2$

$x_6+x_8 \ge 1.13x_7$

$x_6+x_8 + x_6^2 + x_8^2 \ge 1.13x_7 + 1.13x_7^2$

$x_6+x_7 \ge 4x_8$

$x_6+x_7 + x_6^2 + x_7^2 \ge 4x_8 + 4x_8^2$

$x_6 \ge 0, x_7 \ge 0, x_8 \ge 0, x_6^2 \in \mathrm{R}, x_7^2 \in \mathrm{R}, x_8^2 \in \mathrm{R}$

c) For Demersal fish

$Max\ s(x) = 10^3[883x_9+652x_{10}+795x_{11}+448x_{12}+517x_{13}+695x_{14}+755x_{15}+803x_{16}+614x_{17}+592x_{18}+1229x_{19}+1005x_{20}+655x_{21}+2130x_{22}+1114x_{23}+998x_{24}+635x_{25}+366x_{26}+741x_{27}+456x_{28}+1271x_{29}+993x_{30}+562x_{31}+1377x_{32}+328x_{33}+888x_{34}+667x_{35}+578x_{36}+926x_{37}+285x_{38}+646x_{39}+489x_{40}+628x_{41}+294x_{42}+846x_9^2+660x_{10}^2+779x_{11}^2+438x_{12}^2+504x_{13}^2+707x_{14}^2+749x_{15}^2+777x_{16}^2+584x_{17}^2+582x_{18}^2+1235x_{19}^2+1031x_{20}^2+676x_{21}^2+2101x_{22}^2+1078x_{23}^2+1024x_{24}^2+629x_{25}^2+355x_{26}^2+725x_{27}^2+451x_{28}^2+1273x_{29}^2+1007x_{30}^2+568x_{31}^2+1404x_{32}^2+346x_{33}^2+863x_{34}^2+746x_{35}^2+577x_{36}^2+944x_{37}^2 +275x_{38}^2+624x_{39}^2+502x_{40}^2+619x_{41}^2+287x_{42}^2]$

Subject to:

$78141 \le x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \le 89862.2$

$82311 \le x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \le 94658$

$x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}=124x_9$

$x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \ge 124x_9 + 124x_9^2$

$x_9+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \ge 89.9x_{10}$

$x_9+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \ge 89.9x_{10} + 89.9x_{10}^2$

$$x_9+x_{10}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 57.8x_{11}$$

$$x_9+x_{10}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 57.8x_{11}+57.9x_{11}^2$$

$$x_9+x_{10}+x_{11}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{12}$$

$$x_9+x_{10}+x_{11}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 99x_{12}+99x_{12}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 99x_{13}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 99x_{13}+99x_{13}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 70.4x_{14}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 70.4x_{14}+70.4x_{14}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 110.4x_{15}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 110.4x_{15}+110x_{15}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 4.75x_{16}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 4.75x_{16}+4.7x_{16}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 11.99x_{17}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 11.99x_{17}+11.99x_{17}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 999x_{18}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 999x_{18}+999x_{18}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 27.6x_{19}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2\geq 27.6x_{19}+27.6x_{19}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}\geq 51.6x_{20}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{21}^2+x_{22}^2+x_{23}^2+$$

$x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 51.6x_{20} + 51.6x_{20}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 110x_{21}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}++x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 110 \quad x_{21} + 110x_{21}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 249x_{22}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 249x_{22} + 249x_{22}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 82.3x_{23}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 82.3x_{23} + 82.3x_{23}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 199x_{24}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 199x_{24} + 199x_{24}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 57.8x_{25}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 57.8x_{25} + 57.8x_{25}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 10.4x_{26}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{27}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 10.4x_{26} + 10.4x_{26}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 199x_{27}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{28}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 199x_{27} + 199x_{27}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 141.9x_{28}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{29}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 141.9x_{28} + 141.9x_{28}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 99x_{29}$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} + x_9^2 + x_{10}^2 + x_{11}^2 + x_{12}^2 + x_{13}^2 + x_{14}^2 + x_{15}^2 + x_{16}^2 + x_{17}^2 + x_{18}^2 + x_{19}^2 + x_{20}^2 + x_{21}^2 + x_{22}^2 + x_{23}^2 + x_{24}^2 + x_{25}^2 + x_{26}^2 + x_{27}^2 + x_{28}^2 + x_{30}^2 + x_{31}^2 + x_{32}^2 + x_{33}^2 + x_{34}^2 + x_{35}^2 + x_{36}^2 + x_{37}^2 + x_{38}^2 + x_{39}^2 + x_{40}^2 + x_{41}^2 + x_{42}^2 \geq 99x_{29} + 99x_{29}^2$

$x_{9}+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 6.8x_{30}$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 6.8x_{30}+x_{30}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 65.7x_{31}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 65.7x_{31}+65.7x_{31}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 40.7x_{32}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 40.7x_{32}+40.7x_{32}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 110x_{33}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 110x_{33}+110x_{33}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 70.4x_{34}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 70.4x_{34}+70.4x_{34}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 332.3x_{35}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 332.3x_{35}+332.3x_{35}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 999x_{36}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 999x_{36}+999x_{36}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42} \geq 99x_{37}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{38}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 99x_{37}+99x_{37}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{39}+x_{40}+x_{41}+x_{42} \geq 70.4x_{38}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{39}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{39}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 70.4x_{38}+70.4x_{38}^2$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{40}+x_{41}+x_{42} \geq 26x_{39}$$

$$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{40}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{40}^2+x_{41}^2+x_{42}^2 \geq 26x_{39}+26x_{39}^2$$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{41}+x_{42}\geq 39x_{40}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{41}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{41}^2+x_{42}^2\geq 39x_{40}+39x_{40}^2$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{42}\geq 499x_{41}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{42}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{42}^2\geq 499x_{41}+499x_{41}^2$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}\geq 4.6x_{42}$

$x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{30}+x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}+x_{38}+x_{39}+x_{40}+x_{41}+x_9^2+x_{10}^2+x_{11}^2+x_{12}^2+x_{13}^2+x_{14}^2+x_{15}^2+x_{16}^2+x_{17}^2+x_{18}^2+x_{19}^2+x_{20}^2+x_{21}^2+x_{22}^2+x_{23}^2+x_{24}^2+x_{25}^2+x_{26}^2+x_{27}^2+x_{28}^2+x_{29}^2+x_{30}^2+x_{31}^2+x_{32}^2+x_{33}^2+x_{34}^2+x_{35}^2+x_{36}^2+x_{37}^2+x_{38}^2+x_{39}^2+x_{40}^2+x_{41}^2\geq 4.6x_{42}+4.6x_{42}^2$

$x_9\geq 0, x_{10}\geq 0, x_{11}\geq 0, x_{12}\geq 0, x_{13}\geq 0, x_{14}\geq 0, x_{15}\geq 0, x_{16}\geq 0, x_{17}\geq 0, x_{18}\geq 0, x_{19}\geq 0, x_{20}\geq 0, x_{21}\geq 0, x_{22}\geq 0, x_{23}\geq 0, x_{24}\geq 0, x_{25}\geq 0, x_{26}\geq 0, x_{27}\geq 0, x_{28}\geq 0, x_{29}\geq 0, x_{30}\geq 0, x_{31}\geq 0, x_{32}\geq 0, x_{33}\geq 0, x_{34}\geq 0, x_{35}\geq 0, x_{36}\geq 0, x_{37}\geq 0, x_{38}\geq 0, x_{39}\geq 0, x_{40}\geq 0, x_{41}\geq 0, x_{42}\geq 0,$
$x_9^2\in R, x_{10}^2\in R, x_{11}^2\in R, x_{12}^2\in R, x_{13}^2\in R, x_{14}^2\in R, x_{15}^2\in R, x_{16}^2\in R, x_{17}^2\in R,$
$x_{18}^2\in R, x_{19}^2\in R, x_{20}^2\in R, x_{21}^2\in R, x_{22}^2\in R, x_{23}^2\in R, x_{24}^2\in R, x_{25}^2\in R, x_{26}^2\in R, x_{27}^2\in R, x_{28}^2\in R, x_{29}^2\in R,$
$x_{30}^2\in R, x_{31}^2\in R, x_{32}^2\in R, x_{33}^2\in R, x_{34}^2\in R, x_{35}^2\in R, x_{36}^2\in R, x_{37}^2\in R, x_{38}^2\in R, x_{39}^2\in R, x_{40}^2\in R, x_{41}^2\in R, x_{42}^2\in R$

d) For Pelagic fish

$Max\ s(x)=10^3[640.4x_{43}+334.7x_{44}+419x_{45}+732.3x_{46}+404.7x_{47}+376x_{48}+626.3x_{43}^2+339.5x_{44}^2+412x_{45}^2+699.8x_{46}^2+389.6x_{47}^2+366x_{48}^2]$

Subject to:

$249327\leq x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{48}\leq 286726.1$

$246641\leq x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{48}+x_{43}^2+x_{44}^2+x_{45}^2+x_{46}^2+x_{47}^2+x_{48}^2\leq 283637.15$

$x_{44}+x_{45}+x_{46}+x_{47}+x_{48}\geq 2x_{43}$

$x_{44}+x_{45}+x_{46}+x_{47}+x_{48}+x_{44}^2+x_{45}^2+x_{46}^2+x_{47}^2+x_{48}^2\geq 2x_{43}+2x_{43}^2$

$x_{43}+x_{45}+x_{46}+x_{47}+x_{48}\geq 9.2x_{44}$

$x_{43}+x_{45}+x_{46}+x_{47}+x_{48}-x_{43}^2+x_{43}^2+x_{45}^2+x_{46}^2+x_{47}^2+x_{48}^2\geq 9.2x_{44}+9.2x_{44}^2$

$x_{43}+x_{44}+x_{46}+x_{47}+x_{48}\geq 12.9x_{45}$

$x_{43}+x_{44}+x_{46}+x_{47}+x_{48}+x_{43}^2+x_{44}^2+x_{46}^2+x_{47}^2+x_{48}^2\geq 12.9x_{45}+12.9x_{45}^2$

$x_{43}+x_{44}+x_{45}+x_{47}+x_{48}\geq 39x_{46}$

$x_{43}+x_{44}+x_{45}+x_{47}+x_{48}+x_{43}^2+x_{44}^2+x_{45}^2+x_{47}^2+x_{48}^2\geq 39x_{46}+39x_{46}^2$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{48}\geq 0.84x_{47}$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{48}+x_{43}^2+x_{44}^2+x_{45}^2+x_{46}^2+x_{48}^2\leq\geq 0.84x_{47}+0.84x_{47}^2$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{47}\geq 39x_{48}$

$x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{43}^2+x_{44}^2+x_{45}^2+x_{46}^2+x_{47}^2\leq\geq 39x_{48}+39x_{48}^2$

$x_{43}\geq 0, x_{44}\geq 0, x_{45}\geq 0, x_{46}\geq 0, x_{47}\geq 0, x_{48}\geq 0, x_{43}^2\in R, x_{44}^2\in R, x_{45}^2\in R, x_{46}^2\in R,$
$x_{47}^2\in R, x_{48}^2\in R$

e) For Freshwater fishing

$Max\ s(y)=1000(448y_1+1229y_2+285y_3+328y_4+888y_5+438y_1^2+1235y_2^2+275y_3^2+346y_4^2+863y_5^2)$

Subject to:

$15478\leq y_1+y_2+y_3+y_4+y_5\leq 17799.7$

$15048\leq y_1+y_2+y_3+y_4+y_5+y_1^2+y_2^2+y_3^2+y_4^2+y_5^2\leq 17305$

$y_2+y_3+y_4+y_5\geq 0.92y_1$

$y_2+y_3+y_4+y_5+y_2^2+y_3^2+y_4^2+y_5^2\geq 0.92y_1+0.92y_1^2$

$y_1+y_3+y_4+y_5\geq 2y_2$

$y_1+y_3+y_4+y_5+y_1^2+y_3^2+y_4^2+y_5^2\geq 2y_2+2y_2^2$

$y_1+y_2+y_4+y_5\geq 8y_3$

$y_1+y_2+y_4+y_5+y_1^2+y_2^2+y_4^2+y_5^2\geq 8y_3+8y_3^2$

$y_1+y_2+y_3+y_5\geq 99y_4$

$y_1+y_2+y_3+y_5+y_1^2+y_2^2+y_3^2+y_5^2\geq 99y_4+99y_4^2$

$y_1+y_2+y_3+y_4\geq 32.3y_5$

$y_1+y_2+y_3+y_4+y_1^2+y_2^2+y_3^2+y_4^2\geq 32.3y_5+32.3y_5^2$

$y_1 \geq 0, y_2 \geq 0, y_3 \geq 0, y_4 \geq 0, y_5 \geq 0, y_1^2 \in \mathrm{R}, y_2^2 \in \mathrm{R}, y_3^2 \in \mathrm{R}, y_4^2 \in \mathrm{R}, y_5^2 \in \mathrm{R}$

6. Results, Generation of New Jobs and Discussion

6.1. Results of the First Stage Models

Table 3. *Results of the crustaceans sell model.*

Code	Decision variables	Results
x_1	Striped grunt	1,707.5
x_2	Shrimp	457.83
x_3	Crab	1,292.31
x_4	Coastal Shrimp	583.5
x_5	Lobster	125.11
Tons sold		4,166.22
Revenue		7,601,623,730.7 KZ

Exchange rate: 1 USD = 834 Kz on august 27, 2023

KZ 7,601,623,730.7 would be the optimal annual income, from 2016 to 2022, for the sale of 4 166.22 tons of crustaceans, of which 1 707.5 for Striped grunt, 457.83 for Shrimp, 1,292.31 for Crab, 583.5 for Coastal Shrimp, and 125.11 for Lobster.

Table 4. *Validation of the Crustacean revenue model for the year 2018 data.*

Code	Decision variables	Results without model	Results with model	Increment
x_1	Striped grunt	917	1,777.9	
x_2	Shrimp	786.25	476.7	
x_3	Crab	1 388	1,345.6	
x_4	Coastal Shrimp	365.5	607.6	
x_5	Lobster	230.35	130.3	
Revenue		6,056,519,450 Kz	7,915,050,991.96 Kz	31%

Unlike the annual income of Kz 6,056,519,450 collected in 2018, the present model for optimizing crustacean revenue would provide us with Kz 7,915,050,991.96, with an increase of 31%, which shows the validity of the same model.

Table 5. *Results of the Mollusks sell model.*

Code	Decision variables	Results
x_6	Cuttlefish	815.35
x_7	Squid	1141.49
x_8	Octopus	489.21
Tons sold		2,446.1
Revenue		2,529,541,841.03 Kz

2 529 541 841.03 Kz would be the optimal annual income, from 2016 to 2022, for the sale of 2 446.1 tons, 815.35 for cuttlefish, 1141.49 for squid, and 489.21 for octopus.

Table 6. *Validation of the Mollusks sell model for the 2018 data.*

Code	Decision variables	Results with model	Results without model	Increment
x_6	Cuttlefish	1322.7	1124.27	
x_7	Squid	1851.73	1573.97	
x_8	Octopus	793.6	674.56	
Revenue		4,103,441,066.67 Kz	3,487,924,906.67 Kz	18%

18% is the increase that would have been gained if the present model had been applied in 2018, providing Kz 4 103 441 066.67 as opposed to Kz 3 487 924 906.67, evidencing the validity of the proposed model for the sale of Mollusks.

Table 7. *Results of the income model with Demersal fish.*

Code	Decision variables	Results	Code	Decision variables	Results	Code	Decision variables	Results
x_9	Needlefish	716.7	x_{21}	Dorado	809.6	x_{33}	Skate	809.6
x_{10}	Anchovy	988.6	x_{22}	Grouper	359.4	x_{34}	Drumfish	1,258.6
x_{11}	Codfish	1,528.3	x_{23}	Flounder	1,078.8	x_{35}	John dory	269.6
x_{12}	Catfish	898.6	x_{24}	Shorthead scorpionfish	449.3	x_{36}	Flying gurnard	89.9
x_{13}	Bolo fish	898.6	x_{25}	Black scalyfin	1,528.3	x_{37}	Skipjack tuna	898.6
x_{14}	Bearded goby	1,258.6	x_{26}	Sand whiting	7,882.6	x_{38}	Chub mackerel	1,045.3

Code	Decision variables	Results	Code	Decision variables	Results	Code	Decision variables	Results
x_{15}	Parrotfish	806.7	x_{27}	Sand steenbras	448.4	x_{39}	Calico grouper	3,328.2
x_{16}	Violet blenny	15,628.2	x_{28}	Kelpfish	628.8	x_{40}	Blenniidae sp.	2,246.6
x_{17}	Bullnose ray	6,917.8	x_{29}	Red snapper	898.6	x_{41}	Shark	179.7
x_{18}	Scrawled filefish	89.9	x_{30}	Hake	11,520.8	x_{42}	Other species	16,046.8
x_{19}	Croaker	3,142	x_{31}	Blackgoby	1,347.3			
x_{20}	Dentex	1,708	x_{32}	Bluefish	2,155			
Tons sold						89,862.2		
Revenue						61,823,637,538.15 Kz		

61,823,637,538.15 Kz would be the optimal annual income, from 2016 to 2022, for the sale of 89,862.2 tons of demersal fish, being 716.7 for Needlefish, 988.6 for Anchovy, 1,528.3 for Codfish, 898.6 for Catfish, 898.6 for Bolo fish, 1,258.6 for Bearded goby, 806.7 for Parrotfish, 15,628.2 for Violet blenny, 6,917.8 for Bullnose ray, 89.9 for Scrawled filefish, 3,142 for Croaker, 1,708 for Dentex, 809.6 for Dorado, 359.4 for Grouper, 1,078.8 for Flounder, 449.3 for Shorthead scorpionfish, 1,528.3 for Black scalyfin, 7,882.6 for Sand whiting, 448.4 for Sand steenbras, 628.8 for Kelpfish, 898.6 for Red snapper, 11,520.8 for Hake, 1,347.3 for Blackgoby, 2,155 for Bluefish, 809.6 for Skate, 1,258.6 for Drumfish, 269.6 for John dory, 89.9 for Flying gurnard, 898.6 for Skipjack tuna, 1,045.3 for Chub mackerel, 3,328.2 for Calico grouper, 2,246.6 for Blenniidae sp, 179.7 for Shark, and 16,046.8 for Other Demersal species.

Table 8. *Validation of the income model of Demersal fish with 2019 data.*

Code	Decision variables	Results with model	Results without model	Code	Decision variables	Results with model	Results without model
x_9	Needlefish	548	113	x_{26}	Sand whiting	6,024	5,436
x_{10}	Anchovy	755	47	x_{27}	Sand steenbras	342.7	430.95
x_{11}	Codfish	1,168	1 594	x_{28}	Kelpfish	480.6	540.6
x_{12}	Catfish	686.74	1 350	x_{29}	Red snapper	687	711
x_{13}	Bolo fish	68674	1 009	x_{30}	Hake	8,804	9,680
x_{14}	Bearded goby	962	1 237	x_{31}	Blackgoby	1,029.6	1,042
x_{15}	Parrotfish	616	907	x_{32}	Bluefish	1,646.9	3,741.7
x_{16}	Violet blenny	11,943	9 890	x_{33}	Skate	618.7	1,377
x_{17}	Bullnose ray	5,287	1 392	x_{34}	Drumfish	962	1,350
x_{18}	Scrawled filefish	68.7	138.6	x_{35}	John dory	206	348.5
x_{19}	Croaker	2,401	2 825	x_{36}	Flying gurnard	68.7	58.7
x_{20}	Dentex	1,306	1 342	x_{37}	Skipjack tuna	686.7	768.4
x_{21}	Dorado	618.7	487.9	x_{38}	Chub mackerel	799	1,153
x_{22}	Grouper	274.7	390.2	x_{39}	Calico grouper	2,543	2,307
x_{23}	Flounder	824	1 577	x_{40}	Blenniidae sp.	1,717	1,573
x_{24}	Shorthead scorpionfish	343.4	249.9	x_{41}	Shark	137.35	298.4
x_{25}	Black scalyfin	1 168	1 885	x_{42}	Other species	12,263	1,124
Revenue with model						47,246,522,834.9 Kz	
Revenue without model						46,663,802,350 Kz	
Increment						1.25%	

In 2019, an additional 1.25% would be gained on Demersal fish income with sales, that is, 47 246 522 834.9 Kz if the model was adopted against the 46 663 802 350 Kz collected, a considerable amount, confirming the validity of the optimization for this category of fish.

Table 9. *Results of the income model of sell with Pelagic fish.*

Cód.	Variáveis de decisão	Resultados
x_{43}	Mackerels	95 575.4
x_{44}	Tuna	357.2
x_{45}	Swordfish	20 627.8
x_{46}	Rooster	7 168.2
x_{47}	Sardines	155 829.4
x_{48}	Other species	7 168.2
Tones sold		286,726.1
Revenue		140,977,697,143.7 Kz

With Pelagic fish, the ticket sales optimization model would provide 140,977,697,143.7 Kz selling 286,726.1 tons, of which 95,575.4 for Mackerels, 357.2 for Tuna, 20,627.8 for Swordfish, 7,168.2 for Rooster, 155,829.4 for Sardines, and 7,168.2 for Other Pelagic species.

Table 10. *Validation of the income model of sell with Pelagic fish with 2018 data.*

Code	Decision variables	Results with model	Results without model	Increment
x_{43}	Mackerels	93 331.3	48 767	
x_{44}	Tuna	348.9	24 289	
x_{45}	Swordfish	20 143.5	32 714	
x_{46}	Rooster	6 999.9	12 784	
x_{47}	Sardines	152 170.7	150 413	
x_{48}	Other species	6 999.9	11 027	
Revenue		137,667,653,325.09 kz	127,447,097,400 Kz	7%

If the pelagic fish optimization model were applied, an increase of around 7% would be observed for 2018 income, a very significant increase. Therefore, the model is valid.

Table 11. *Results of the income model with fish from Freshwater fishing.*

Code	Decision variables	Results
y_1	Catfish	9 270.68
y_2	Rastrineobola	5 933.23
y_3	Mullet	1 883.27
y_4	Turkey	178
y_5	Other species	534.53
Tons sold		17 799.7
Revenue		12,514,979,894.14 Kz

Table 12. *Validation of the Freshwater fishing income model in 2018.*

Code	Decision variables	Results with model	Results without model	Increment
y_1	Catfish	15 120.83	14 993	
y_2	Rastrineobola	9 677.33	9 989	
y_3	Mullet	3 071.68	2661	
y_4	Turkey	290.32	1 198	
y_5	Other species	871.83	191	
Revenue		20,412,416,854.6 Kz	20,314,282,000 Kz	0.5%

With the optimal Freshwater fishing model, annual gains of 12,514,979,894.14 Kz would be observed selling 17,799.7 tons, of which 9,270.68 of Catfish, 5,933.23 of Rastrineobola, 1,883.27 of Mullet, 178 of Turkey, and 534.53 from Others Species of Freshwater fishing.

In Freshwater fishing there would be only 0.5% or 98,134,854.6 Kz of increase if the model was adopted. Despite this, it is still relevant for income of sales, which also validates the model.

6.2. Results of Two-Stage Optimization Models

For the two-stage optimization models, in which both variables intervene in each of the categories of fish under analysis, the results in Table 13, Table 14, Table 15, Table 16 and Table 17 were observed.

Table 13. *Results of the two-stage optimization model with Crustacean sales.*

Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage
	x_i	x_i^2
Striped grunt	1 485	0
Shrimp	398	0
Crab	1 124	0
Coastal Shrimp	507	470
Lobster	109	0
Tones to sell	3 623	470
Revenue	8,480,165,392 Kz	

In the current scenario, Crustaceans will produce an optimal revenue of 8,480,165,392 Kz selling in the first stage 3,623 tons of which 1,485 of Striped grunt, 398 of Shrimp, 1,124 of Crab, 507 of Coastal Shrimp and 109 of Lobster. In the second stage, 470 tons should be sold, all of Coastal Shrimp.

Table 14. *Results of the two-stage optimization model with Mollusks sell.*

Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage
	x_i	x_i^2
Cuttlefish	808	29
Squid	1 148	-60

Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage
	x_i	x_i^2
Octopus	489	-97
Tones to sell	2 446	-128
Revenue	2,403,145,469 Kz	

Mollusks will be able to produce, in the current scenario, income in the order of 2,403,145,469 Kz, selling 2,446 tons in the first stage, of which 808 of Cuttlefish, 1,148 Squid and 489 of Octopus. In the second stage there will be a reduction of 128 tons, 60 in Squid and 97 in Octopus, although 29 tons of Cuttlefish will be sold.

Table 15. *Results of the two-stage optimization model with the sale of Demersal fish.*

Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage	Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage
	x_i	x_i^2		x_i	x_i^2
Needlefish	623	134	Sand whiting	7,104	1,502
Anchovy	859	182	Sand steenbras	0	473
Codfish	1,324	280	Kelpfish	483	179
Catfish	781	165	Red snapper	781	165
Bolo fish	781	165	Hake	9,768	2,065
Bearded goby	1,101	233	Blackgoby	1,166	247
Parrotfish	704	-9,073	Bluefish	1,861	393
Violet blenny	13,024	61,881	Skate	704	149
Bullnose ray	6,011	1,271	Drumfish	1,101	233
Scrawled filefish	0	95	John Dory	235	50
Croaker	2,695	570	Flying gurnard	78	17
Dentex	1,474	312	Skipjack tuna	781	165
Dorado	704	149	Chub mackerel	1,101	233
Grouper	0	379	Calico grouper	2,894	612
Flounder	941	199	Blenniidae sp.	1,954	413
Shorthead scorpionfish	0	473	Shark	156	-1,761
Black scalyfin	1,324	253	Other species	15,628	-46,281
Tones would be sell in the first stage				78,141	
Tones to sell in the first stage				16,517	
Revenue				88,507,944,198 Kz	

In the current scenario, 88,507,944,198 Kz will be the optimal annual income with Demersal fish, from 2016 to 2050, selling 78,141 tons per year in the first stage (2022-2022) of which 623 for Needlefish, 859 for Anchovy, 1,324 for Codfish, 781 for Catfish, 781for Bolo fish, 1,101 for Bearded goby, 704 for Parrotfish, 13,024 for Violet blenny, 6,011 for Bullnose ray, 2,695 for Croaker, 1,474 for Dentex, 704 for Dorado, 941 for Flounder, 1,324 for Black scalyfin, 7,104 for Sand whiting, 483 for Kelpfish, 781 for Red snapper, 9,768 for Hake, 1,347.3 for Blackgoby, 1,861 for Bluefish, 704 for Skate, 1,101 for Drumfish, 235 for John Dory, 78 for Flying gurnard, 781 for Skipjack tuna, 1,101 for Chub mackerel, 2,894 for Calico grouper, 1,954 for Blenniidae sp, 156 for Shark, and 15,628 for Other Demersal species.

In the second stage, from 2023 to 2050, 16,517 tons should be sold annually, 134 of Needlefish, 182 of Anchovy, 280 of Codfish, 165 of Catfish, 165 Bolo fish, 233 of Bearded goby, 61,881 of Violet blenny, 1,271 of Bullnose ray, 95 of Scrawled filefish, 570 of Croaker, 312 of Dentex, 149 of Dorado, 379 of Grouper, 199 of Flounder, 473 of Shorthead scorpionfish, 253 of Black scalyfin, 1,502 of Sand whiting, 473 of Sand steenbras, 179 of Kelpfish, 165 of Red snapper, 2,065 of Hake, 247 of Blackgoby, 393 of Bluefish, 149 of Skate, 233 of Drumfish, 50 of John Dory, 17 of Flying gurnard, 165 of Skipjack tuna, 233 of Chub mackerel, 612 of Calico grouper, 413 of Blenniidae sp, observing a reduction of 9,073 tons of Parrotfish, 1,761 of Shark, and 46,281 of Other Demersal species.

Table 16. *Results of the two-stage optimization model with sale of Pelagic Fish.*

Decision variables	Results of the decision variable for the first stage	Results of the decision variable for the second stage
	x_i	x_i^2
Mackerels	128 909	-34 363
Tuna	482	-128
Swordfish	27 822	-7 416
Rooster	9 668	-2 577
Sardines	210 177	-56 027
Other species	9 668	-2 577
Tones to sell	386 726	-103 089
Revenue	140,950,270,511 Kz	

In the current scenario, with Pelagic fish, income will be produced in the order of 140,950,270,511 Kz, selling in the first stage 386,726 tons, of which 128,909 of Mackerels, 482 of Tuna, 27,822 of Swordfish, 9 668 of Rooster, 210,177 of Sardines, and 9,668 of Other pelagic species.

In the second stage, a reduction of 103,089 tons in sales will be observed, which 34,363 of Mackerels, 128 of Tuna, 7,416 of Swordfish, 2,577 of Rooster, 56,027 of Sardines, and 2,577 of Other pelagic species.

Table 17. *Results of the two-stage optimization model of sell with Freshwater fishing fish.*

Decision variables	Results of the decision variable for the first stage y_i	Results of the decision variable for the second stage y_i^2
Catfish	15 121	-7 283
Rastrineobola	9 677	-4 661
Mullet	3072	-1 480
Turkey	290	-140
Other species	872	-420
Tones to sell	29 032	-13 984
Revenue	20,412,416,855 Kz	

For the current scenario, with Freshwater Fishing, revenue will be obtained in the order of 20,412,416,855 Kz, selling in the first stage 29,032 tons, of which 15,121 from Catfish, 9,677 from Rastrineobola, 3072 from Mullet, 290 from Turkey, and 872 from Other species from.

In the second stage, a reduction of 13,984 tons in sales will be observed, of which 7,283 are from Catfish, 4,661 from Rastrineobola, 1,480 from Mullet, 140 from Turkey, and 420 from Other species of Continental Fisheries.

In general, in the current scenario in Angola, the fishing sector will be able to produce a Primer with optimal annual revenues of 260,753,942,425 Kz as opposed to the expected 246,617,594,646.47 Kz, being 3% for Crustaceans, 1% for Mollusks, 34% for Demersal fish, 54% for Pelagic fish and 8% for Freshwater fishing. Optimal revenue would provide an increase of 5.73%.

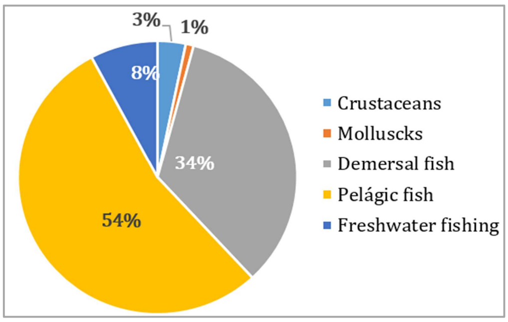

Figure 9. *Optimal Portfolio of annual income with fish selling for Angola until 2050.*

6.3. Results of New Jobs Generation

According to [16, 17, 18], the fishing sector recorded 113,368 jobs, with 88,252 self-employments for fishermen and 25,116 jobs for women fish processors. Fishermen are distributed among 3,651 in Industrial Fisheries, 1,173 in Semi-industrial fisheries, 47,926 in maritime artisanal fisheries and 35,502 in freshwater artisanal fisheries. There were 2,057 fish processors in Industrial fisheries, 4,379 in Semi-Industrial fisheries, 10,460 in maritime artisanal fisheries and 8,219 in freshwater artisanal fisheries. As income will grow by 5.73% annually from 2023 to 2050, jobs will grow at the same rate annually, with the following being observed:

New jobs per year: 113 368x5.73%=6514

New Fishermen per year: $\frac{88\,252}{113\,368} \times 6\,514 = 5\,071$

New fish processors per year: $\frac{25\,116}{113\,368} \times 6\,514 = 1\,443$

Industrial fishermen per year: $\frac{3\,651}{113\,368} \times 6\,514 = 210$

New semi-industrial fishermen per year: $\frac{1\,173}{113\,368} \times 6\,514 = 67$

New artisanal maritime fishermen per year: $\frac{47\,926}{113\,368} \times 6\,514 = 2\,754$

New Freshwater artisanal fishermen per year: $\frac{35\,502}{113\,368} \times 6\,514 = 2\,040$

New fish processors per year: $\frac{2\,057}{113\,368} \times 6\,514 = 118$

New fish processors per year: $\frac{4\,379}{113\,368} \times 6\,514 = 252$

New artisanal maritime fish processors per year: $\frac{10\,460}{113\,368} \times 6\,514 = 601$

New Freshwater artisanal fish processors per year: $\frac{8\,219}{113\,368} \times 6\,514 = 472$

Table 18. *Distribution of new jobs in fishing per year in the current scenario in Angola.*

	Industrial fishing	Semi-industrial fishing	Artisanal fishing		SUBTOTAL
			Maritime	Freshwater	
Fishermen	210	67	2,754	2,040	5,071
Fish processors	118	252	601	472	1,443
TOTAL	328	319	3,355	2,512	6,514

The total value of results from the income optimization models of the two stages will generate 6,514 new jobs and direct self-employment annually, of which 328 in industrial fishing, 319 in semi-industrial fishing, 3,355 in artisanal maritime fishing and 2,512 in freshwater fishing. 5,071 will be fishermen, of which 210 will be industrial fishing, 67 will be in semi-industrial fishing, 2,754 will be in maritime artisanal fishing and 2,040 will be in freshwater artisanal fishing. 1,443 jobs will be for women fish processors, of which 118 will be for industrial fishing, 252 for semi-industrial fishing, 601 for maritime artisanal fishing and 472 for freshwater artisanal fishing.

7. Conclusion

This article only analyzed the current scenario divided in two subperios, 2016-2022 (first stage) and 2023-2050 (second stage), of the 3 notable possible scenarios of fishing in Angola, which is one of the non-oil sectors with a lot of potential to generate revenue and a significant number of jobs. For this purpose, mathematical optimization and prediction models, or algorithms, must be adopted to generate in the current scenario up to 2050 annual sales tickets in the order of 260,753,942,425 Kz as opposed to the 246,617,594,646.47 Kz currently achieved.

The 5 Crustaceans will produce an optimal revenue of 8,480,165,392 Kz selling in the first stage 3,623 tons of which 1,485 of Striped grunt, 398 of Shrimp, 1,124 of Crab, 507 of Coastal Shrimp and 109 of Lobster. In the second stage, 470 tons should be sold, all of Coastal Shrimp.

The 3 Mollusks will be able to produce, in the current scenario, income in the order of 2,403,145,469 Kz, selling 2,446 tons in the first stage, of which 808 of Cuttlefish, 1,148 Squid and 489 of Octopus. In the second stage there will be a reduction of 128 tons, 60 in Squid and 97 in Octopus, although 29 tons of Cuttlefish will be sold.

88,507,944,198 Kz will be the optimal annual income with 34 Demersal fish, selling 78,141 tons per year in the first stage, of which 623 for Needlefish, 859 for Anchovy, 1,324 for Codfish, 781 for Catfish, 781for Bolo fish, 1,101 for Bearded goby, 704 for Parrotfish, 13,024 for Violet blenny, 6,011 for Bullnose ray, 2,695 for Croaker, 1,474 for Dentex, 704 for Dorado, 941 for Flounder, 1,324 for Black scalyfin, 7,104 for Sand whiting, 483 for Kelpfish, 781 for Red snapper, 9,768 for Hake, 1,347.3 for Blackgoby, 1,861 for Bluefish, 704 for Skate, 1,101 for Drumfish, 235 for John dory, 78 for Flying gurnard, 781 for Skipjack tuna, 1,101 for Chub mackerel, 2,894 for Calico grouper, 1,954 for Blenniidae sp, 156 for Shark, and 15,628 for Other Demersal species. In the second stage, 16,517 tons should be sold annually, 134 of Needlefish, 182 of Anchovy, 280 of Codfish, 165 of Catfish, 165 Bolo fish, 233 of Bearded goby, 61,881 of Violet blenny, 1,271 of Bullnose ray, 95 of Scrawled filefish, 570 of Croaker, 312 of Dentex, 149 of Dorado, 379 of Grouper, 199 of Flounder, 473 of Shorthead scorpionfish, 253 of Black scalyfin, 1,502 of Sand whiting, 473 of Sand steenbras, 179 of Kelpfish, 165 of Red snapper, 2,065 of Hake, 247 of Blackgoby, 393 of Bluefish, 149 of Skate, 233 of Drumfish, 50 of John Dory, 17 of Flying gurnard, 165 of Skipjack tuna, 233 of Chub mackerel, 612 of Calico grouper, 413 of Blenniidae sp, observing a reduction of 9,073 tons of Parrotfish, 1,761 of Shark, and 46,281 of Other Demersal species.

The 6 Pelagic fish will be able to provide 140,950,270,511 Kz, selling in the first stage 386,726 tons, of which 128,909 of Mackerels, 482 of Tuna, 27,822 of Swordfish, 9 668 of Rooster, 210,177 of Sardines, and 9,668 of Other pelagic species. In the second stage, a reduction of 103,089 tons in sales will be observed, which 34,363 of Mackerels, 128 of Tuna, 7,416 of Swordfish, 2,577 of Rooster, 56,027 of Sardines, and 2,577 of Other pelagic species.

With the 5 fish from with freshwater fishing, revenue will be obtained in the order of 20,412,416,855 Kz, selling in the first stage 29,032 tons, of which 15,121 from Catfish, 9,677 from Rastrineobola, 3072 from Mullet, 290 from Turkey, and 872 from Other species from. In the second stage, a reduction of 13,984 tons in sales will be observed, of which 7,283 are from Catfish, 4,661 from Rastrineobola, 1,480 from Mullet, 140 from Turkey, and 420 from Other species of Continental Fisheries.

Fishing sector of Angola will be able to produce a optimal annual revenues of 260,753,942,425 Kz as opposed to the expected 246,617,594,646.47 Kz, being 3% for Crustaceans, 1% for Mollusks, 34% for Demersal fish, 54% for Pelagic fish and 8% for Freshwater fishing. Optimal revenue would provide an increase of 5.73%, generating 6,514 new jobs and direct self-employment annually, of which 328 in industrial fishing, 319 in semi-industrial fishing, 3,355 in artisanal maritime fishing and 2,512 in freshwater fishing. 5,071 will be fishermen, of which 210 will be industrial fishing, 67 will be in semi-industrial fishing, 2,754 will be in maritime artisanal fishing and 2,040 will be in freshwater artisanal fishing. 1,443 jobs will be for women fish processors, of which 118 will be for industrial fishing, 252 for semi-industrial fishing, 601 for maritime artisanal fishing and 472 for freshwater artisanal fishing.

References

[1] Centeno, M. (2000). O auto emprego será a resposta a rigidez do mercado de trabalho, Banco de Portugal, Boletim económico. Available in https://www.bportugal.pt/paper/o-auto-emprego-sera-resposta-rigidez-do-mercado-de-trabalho

[2] David J. Rader (2013). Deterministic Operations Research: Models and Methods in Linear Optimization, ISBN: 978-1-118-62735-8, Wiley. https://www.wiley.com/en-cn/Deterministic+Operations+Research%3A+Models+and+Methods+in+Linear+Optimization-p-9781118627358

[3] Mark W. Spong (2023). Introduction to Modeling and Simulation: A Systems Approach, SBN: 978-1-119-98290-6, Wiley. Available in https://books.wiley.com/titles/9781119982883/

[4] Ana Paula Ribeiro dos Santos e Lilyan Rosmery Luizaga de Monteiro (2020). Um Olhar Sobre a pesca artesanal e a gestão dos recursos naturais. PRACS: Revista Eletrônica de Humanidades do Curso de Ciências Sociais da UNIFAP, https://periodicos.unifap.br/index.php/pracs ISSN 1984-4352 Macapá, v. 13, n. 3, p. 227-248, jul./dez. 2020. Available in https://periodicos.unifap.br/index.php/pracs/article/view/6115

[5] Miguel Morais (2009). Análise Técnica, Biófisica e Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango Peixes E Pesca Fluvial Da Bacia Do Okavango Em Angola. OKACOM. Available in https://iwlearn.net/resolveuid/f09cddb74d170756573cf3cc9a93d8b5

[6] Ministério das Pescas da República de Angola (2004). Lei dos Recursos Biológicos Aquáticos (nova lei das pescas), Lei n.º 6A/04 de 8 de Outubro. Luanda-Angola. Available in https://docplayer.com.br/47345-Lei-dos-recursos-biologicos-aquaticos-nova-lei-das-pescas-publicada-no-diario-da-republica-no-81-i-serie-suplemento-assembleia-nacional.html

[7] Julliane dos Santos Fuly (2007). Motivação e Dificuldades Relativas ao auto emprego: Questões de genero. Available in https://www.puc-rio.br/ensinopesq/ccpg/pibic/relatorio_resumo2007/resumos/ADM/juliane_santos.pdf

[8] Christos H. Skiadas, James R. Bozeman (2019). Data Analysis and Applications 1: Clustering and Regression, Modeling - estimating, Forecasting and Data Mining, Print ISBN: 9781786303820 |Online ISBN: 9781119597568 |DOI: 10.1002/9781119597568, © ISTE Ltd 2019, Wiley. Available in https://onlinelibrary.wiley.com/doi/book/10.1002/9781119597568

[9] Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci (2015), Introduction to Time Series Analysis and Forecasting, 2nd Edition, ISBN: 978-1-118-74511-3, Wiley. Available in https://www.wiley.com/en-us/Introduction+to+Time+Series+Analysis+and+Forecasting%2C+2nd+Edition-p-9781118745111

[10] George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel and Greta M. Ljung (2015) Time Series Analysis: Forecasting and Control,5th Edition, by. Published by John Wiley and Sons Inc., Hoboken, New Jersey, pp. 712. ISBN: 978-1-118-67502-1. Available in https://www.researchgate.net/publication/299459188_Time_Series_Analysis_Forecasting_and_Control5th_Edition_by_George_E_P_Box_Gwilym_M_Jenkins_Gregory_C_Reinsel_and_Greta_M_Ljung_2015_Published_by_John_Wiley_and_Sons_Inc_Hoboken_New_Jersey_pp_712_ISBN_

[11] George W. Snecdecor, William G. Cochran (1991). Statistical Methods, 8th Edition, Wiley. Available in https://www.wiley.com/en-us/Statistical+Methods%2C+8th+Edition-p-9780813815619

[12] José Luís Charrua dos Santos (2011). Modelação de Séries Temporais em R, Séries com Suporte em Números Reais e Números Inteiros. Dissertação de Mestrado apresentada na Universidade de Évora, Évora-Portugal. Available in https://dspace.uevora.pt/rdpc/handle/10174/17845

[13] Daniel Peña (2010). Análisis de series temporales, ISBN 8420669458, 9788420669458, Alianza Editorial, 2ª Edición. Análisis de series temporales. Available in https://books.google.co.ao/books/about/An%C3%A1lisis_de_series_temporales.html?id=0VD5tgAACAAJ&redir_esc=y

[14] Fernando Itano, Soane Mota dos Santos. Tópicos de Estatística utilizando R, Instituto de Matemática e Estatistica Universidade de São Paulo, available from 2013 at htt//www.studio.com/pt-br/document/universidade-federal-de-pernambuco/econometria/livro-de-r/3267674

[15] Pizzolato, N. D; Gandolpho, A. A (2009). Técnicas de Otimização. Rio de Janeiro: LTC - Livros Técnicos e Científicos Editora S. A, 2009. RFT28092017. Available in https://www.travessa.com.br/tecnicas-de-otimizacao-1-ed-2009/artigo/2fbeda41-f21c-4fef-98df-d25e315df915

[16] Ministério das Pescas e do Mar da República de Angola (2016). Anuário de Estatísticas das Pescas em Angola, Luanda/Angola. Available in https://www.ine.gov.ao/Arquivos/arquivosCarregados//Carregados/Publicacao_637586852612407176.pdf

[17] Instituto Nacional de Estatística da República de Angola (2022). Relatório dos Resultados das Explorações Agro-Pecuárias/Piscatórias e Aquícolas Familiares Volume III, Setembro 2022, Luanda/Angola. Available in https://www.ine.gov.ao/publicacoes/detalhes/MTAyODQ%3D

[18] Ministério da Agricultura e Pescas da República de Angola (2020). Anuário de Estatísticas das Pescas em Angola, Luanda/Angola. Available in https://www.ine.gov.ao/Arquivos/arquivosCarregados//Carregados/Publicacao_637867472944421600.pdf

[19] Emerson Butyn (2017), Programação Linear Determinística e Estocástica Aplicada ao Problema de Despacho Hidrotérmico. Universidade Federal do Paraná, Curitiba. Available in https://acervodigital.ufpr.br/bitstream/handle/1884/47325/R%20-%20D%20-%20EMERSON%20BUTYN.pdf?sequence=1