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Prediction of maximum yield and estimation the population number of tilapia (*Oreochromis niloticus*) on Alwero reservoir, Gambella, Ethiopia

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Abstract
Global water bodies are suffering from excessive overfishing, exerted by an increasing demand of the population. In order to follow up the status of fishery, stock assessment and estimation of optimum yield is needed for the provision of necessary information for the decision makers to make rational decision on the optimum level of exploitation of fish resources. This study has been conducted on Alwero Reservior one of the Reservoirs found in Gambella Ethiopia. Data was collected on a daily basis for 60 days (from 1-10-2019 to 1-12-2019) from the area where fish were landed. The length composition of tilapia caught by the fishery, total tilapia yield and fishing effort expanded were the basic information collected from the site The aim of the analysis was to estimate the population number of tilapia and fishing mortality coefficient by length group as well as predict the maximum sustainable fish yield and biologically optimum level of fishing pressure for the tilapia stock of the reservoir. Jones length based cohort analysis Model and length-based Thompson and Bell yield Prediction Model have been employed to estimate the maximum sustainable yield with the corresponding biologically optimum fishing effort level. Based on data collected of the fishing pressure on Alwero Reservior, the estimated population number of tilapia were 37.9 million and the predicted values of MSY were 311.63tons/yr and this is obtained at fishing mortality factor of 2.

Keywords: Fishery management, MSY, stock assessment, virtual population analysis, yield prediction

1. Introduction

Ethiopia has an estimated fish production potential of 51 481 ton. However, national per capital fish consumption is very low, being a mere 0.20 kg. Whereas beef is the dominant source of animal protein all over the country, fresh fish is consumed mainly in areas surrounding the Great Rift Valley, south of Addis Ababa, which contains a system of small- to medium-sized lakes.

Lake Tana, nestling at an altitude of 1 830 m, with a mean depth of 9.0 m, surface area of 3 500 km^2 and a shoreline of about 385 km, is the largest water body in the country. And with a potential annual fish yield of 24 900 ton, it is the leading water in fish production, accounting for at least 25 percent of the country's water resource. Insufficient institutional and management capacity, limited resource allocation and investment, poor policy and regulatory framework, and insufficient value chain and fish marketing infrastructure, are some of the cross-sectoral challenges affecting fisheries in Ethiopia. At the same time opportunities exist to increase the global social, health and economic value for fish; to increase demand for fish and fishery products; and to grow intra-regional trade, abound. Despite favourable physical and hydrographic conditions (suitable geographic relief, rich soil quality, good mean annual rainfall, and sufficient freshwater availability), aquaculture production is negligible in Ethiopia. And, in a similar vein, recreational fishing is yet to be adopted as an important form of leisure by the people. Inland sub-sector Catch profile. A high diversity of freshwater fish species is found in Ethiopian waters where at least a hundred local species have been identified. However, only a few of those species – Tilapia, Lates, Barbus, Bagrus, Clarias, and Labeo – form the bulk of the catch, out of which tilapia is the major contributor, yielding about 80 percent of the production FAO [2014] [3]

Gambella People's National Regional State is endowed with large volume and several inland water resources including rivers, lakes, reservoirs, ponds and huge floodplain areas.

The region has four main rivers: Baro, Gillo, Alwero and Akobo. According to some studies, these rivers have a total length of 1,157km and catchment area of 85,738 square km. In addition, the region has two main lakes; namely: Lake Tatta in Gog Woreda and Lake Bishan Waqa in Godere Woreda, and numerous ponds. Lake Tatta has a water surface area of 185ha and located in the right bank floodplain of Gillo River. This huge water resource of the region can be used for various purposes especially for fishery developments [Hussien *et al*., 2010]. Some Study indicates that, the various water resources of the region has a potential in the range of 15,417 and 17,308 tons per year whereby much of the production potential is expected to come from the floodplain areas including L. Tatta, reservoirs & ponds [Hussien *et al*., 2010]

2. Methodology
2.1. Site description
2.1.1. Location
The Gambella People's Regional State (GPNRS) is located south west Ethiopia between geographical coordinates 6028'38" to 8034' North Latitude and 33to 35011’11" East Longitude, which covers an area of about 34,063 km2 about 3% of the nation.

Gambella is the nine region among others region, which constitute Federal Democratic Republic of Ethiopia. It is at a distance of 766 km from Addis Ababa [GPNRS, 2011].

The study area is Abobo Woreda which is found in Anywaa zone. It is one among the five districts. It is located 45 Km from south of Gambella (the capital of the region). The Alwero

Reservoir is formed by damming the Alwero River. It is located at a distance of 6.5km to the west of the Abobo town. At its full supply level, the water surface area reaches 2,210ha and it is made for the purpose of irrigation and fishery development. The reservoir has a capacity to irrigate more than 10,000ha but it is not functioning at the moment owing to the demand of huge outlay to construct the canals among others.

Alwero reservoir is productive and one of the reservoir that found in Gambella region. It has rich phytoplankton and zooplankton community that support large populations of fish species. The most important commercial fish species is *Tilapia (Oreochromis niloticus)*, nile perch (lates niloticus), *Tilapia zilli*, *Heterotis nilotics* and Catfish (*Clarias gariepinus*) that account to the fishery of the reservoir.

2.2. Method of Data Collection
The data was collected from the cooperative fishermen landing site. The data mainly constituted information on the Tilapia fishery of the reservoir that are useful to assess the stock of Tilapia and estimate the maximum sustainable yield of Tilapia and biologically optimum level of fishing effort. Specifically the basic information collected included i) the length composition of Tilapia caught by the fishery, ii) Total Tilapia yield, iii) Fishing effort expanded, iv) Number of fishermen in operation, v) Fishing site.

2.2.1 Sampling regime and data collection
The daily catch and yield data were collected from the fishermen for 60 days. Accordingly, the reservior was visited on a daily basis from *(*1-10-2019 to 1-12-2019).

During each day of sampling, the total lengths of random samples of Tilapia caught by fishermen were measured to the nearest mm. Also the length measured fish were weighed as well as the total catch of each fisherman was weighed. The latter data was then used to estimate the total number of Tilapia caught by the respective fishermen. Other data collected on a daily basis included number of nets set, place of setting as well as number of fishermen operating.

2.3. Data summarization and analysis
The catch statistics data was summarized in a manner useful for stock assessment work using Jones length based cohort analysis model and Length-based Thompson and Bell yield prediction model. The catch statistics data collected of the fishing pressure was analyzed and interpreted. The summarization and analysis were done by using Microsoft Office Excel [2007] software.

2.4. Summarizing length composition data
The length composition catch data of Tilapia was summarized to prepare a table of the average total annual catch of Tilapia distributed by length groups. This was done as follows [Pauly, 1984; Sparre and Venema, 1992] [9]

Preparing length frequency of the sample catch

i. Length measurements recorded daily were grouped into two cm length intervals to prepare a table of the length frequency of Tilapia sampled each day during the sampling occasions.
ii. Ii Estimating the total number of fish landed per day by each fisherman This was estimated by multiplying the number of length measured fish by a conversion factor (W/w) where W= the total weight of the catch of the respective fisherman and w = sample weight of the length measured fish. Thus fish that were simultaneously counted and weighed were used to determine appropriate raising factor to convert records of the daily weight of the catch in to numbers.
iii. Estimating the length composition of the total daily catch This was achieved by multiplying the total numbers caught per day by the relative frequency of each length group in the daily sample obtained under item ‘i’ above. The total length frequency of fish landed during the sampled day was then determined by summing the frequencies of respective length groups. Also the total numbers of fish landed during the sampling days were determined.
iv. Estimating the annual total length composition of fish landed. This was done by multiplying the length frequency of the sampled days catch by an appropriate conversion factor which was equal to C/c, in which ‘C’ = the estimated total catch of fish during the whole year and ‘c’ = the total catch of fish during the sampled days. 181,990 fish were length and weight measured during the 60days of sampling and the length frequency produced using such a large sample size was considered adequate to give a good picture of the length frequency of the catch of Tilapia in the reservoir .

2.4.1. Estimating average weight of fish per length group
The average weights of fish of each length group were approximated using previously established length-weight relationship formula expressed as follows [Yosef, 2002] [12]

$Wt\ (gm) = 0.0184 * L^{3.0197}$

Where Wt is the average weight of each length group, L = the average length of each length group, values of the regression coefficients are a = 0.0184 and b = 3.0197. Then the total weight of fish landed per year in each length group was estimated by multiplying the average weights with the corresponding frequencies of respective length group.

2.4.2. Estimating population sizes and fishing mortalities using the Jones length based cohort analysis

The Jones length based cohort analysis model was used to estimate the population of Tilapia and fishing mortality coefficient by length group. For this the total annual catch distributed by length group was used as the basic input data to get started with the analysis. This was done in three steps as follows

Estimating the population number of the largest length group in the catch

This was done as follows

$N_{terminal} = C_{terminal} * (Z/F)_{Terminal}$

Where

$N_{terminal}$ = the population of the largest length group in the catch

$C_{terminal}$ = the catch of the largest length group and

$(Z/F)_{Terminal}$ = the proportion of the total mortality to the fishing mortality of the largest length group in the catch

Estimating the population numbers of consecutively younger length groups in the catch.

This was done using equation 16 as follows

$N(L1) = [N(L2) * H(L1,L2) + C(L1,L2)] * H(L1,L2)$ 16

Here the terms are as defined earlier.

Estimating the fishing mortality rate of the respective length groups

Fishing mortality values for each length group was estimated using equation 17 as follows.

$F(L1,L2) = (1/\Delta t) * \ln[N(L1)/N(L2)] - M$ 17

Here the terms are also as defined before.

To use Equations 16 and 17, the following input data and parameters were prepared in advance.

i. First a table of the total annual catch distributed by length group was prepared as described earlier
ii. Secondly estimates of the Von Bertalanffy growth parameters namely, L_∞ and k values for the Tilapia stock were as $L_\infty = 35$ cm and $k = 0.28\ yr^{-1}$ [Yosef, 1990, 2002; Demeke 1998] [12].

Thirdly, an estimate of the natural mortality coefficient (M) for Tilapia which is equal to $0.35\ yr^{-1}$ was estimated using Pauly's empirical formula as follows.

$\ln M = -0.00152 - 0.279 * \ln L_\infty + 0.6543 * \ln k + 0.463 * \ln T$

2.4.3. Predicting sustainable fish yield and optimum fishing efforts

The outputs of the above cohort analysis procedures were used as input data for the Thompson and Bell yield prediction model to predict sustainable fish yield at different levels of fishing mortalities [Thompson and Bell, 1934; Pauly and Morgan, 1987; Schnute, 1987; Sparre and Venema, 1992] [11, 7, 8, 9, 10].

For the length based Thompson and Bell model, input data and sources comprised the following

The length composition of the annual total number of fish landed by the fishery. This was obtained from field data collection (catch statistics data record).

Mean weight of the landings per length group. This was estimated by using the mean length of each length group and the length-weight relationship formula developed as described earlier.

Estimates of population numbers of fish and fishing mortality coefficient (F) by length group. Source: results of the Cohort analysis.

An average estimate of natural mortality coefficient (M), and the Von Bertalanffy growth parameters ($L\infty$ and k). Same values as discussed earlier have been used.

The computation procedures of the Thompson and Bell model consisted of two main stages. First the above input data was used to estimate fish yield obtained per year from the respective length group of fish. Summing the individual contribution of each length group gave estimates of the annual total sustainable yield. These estimates pertained to the fishing mortalities that corresponded to the level of fishing effort exerted on the Tilapia stock at the time of sampling.

The second step in the calculation procedure involved assessment of the effects of changes in the current level of fishing effort (and hence that of fishing mortalities) on fish yield. This was done by predicting fish yield at higher and/or lower levels of fishing mortality coefficients pertaining to the respective length groups (F-at-length-array). i.e., the current fishing mortality values of the respective length groups were used as reference and these were increased and/or decreased by a certain raising factor (F-factor) to predict new values of sustainable yield corresponding to the changed fishing mortalities [Venema *et al.*, 1988; Spare and Venema, 1992] [9].

From this analysis, the value of F-factor that gave the maximum sustainable yield was considered as biologically optimum level of fishing mortality to be exerted on the stock. Since there is a one to one correspondence between fishing mortality (F) and fishing effort (f), the value of F-factor chosen as optimum was used to recommend how much the current level of fishing effort need to be increased or decreased to get the maximum sustainable yield from the stocks.

3. Results and Discussion

3.1. Fishing status of the Alwero reservior

There were overall 91 registered cooperative member fishermen operating on the Alwero reservoir during the time of sampling (Table 1). These fishermen owned on average117 nets were set daily on the reservoir. The nets are basically set to catch tilapia but these nets also catch catfish (*Clarias gariepinus*), nile perch (*lates niloticus*), *Tilapia zilli and Heterotis nilotics*. Each net was on average 80 m long and 2.5 m wide and it had an average mesh width of 8 cm stretched mesh. Overall an estimated number of 42,559 nets were operated during the year of sampling (1-10-2019 to 1-12-2019). With this level of fishing effort, an estimated total number of 1,107,106tilapia were caught during the year that weighed about 251,070 kg. The estimated catch per net per day was 26 tilapia and it weighed about 5.7 kg/net/day (Table 1).

Table 1: Statistics of tilapia fishery of Alwero Reservior during the time of sampling

Operation Measurements	Values
Total number of fishermen in operation	91
Average nets set per day	117
Total number of nets set per year	42,559
Total number of fish caught	1,107,106
Total wt. of catch (kg)	251,070
Catch per net (no./net/day)	26
Weight of catch per net (kg/net/day)	5.77

Source: Stock assessment work

3.1.1. Length composition of the sampled catch and estimated annual catch

Tilapia measuring in length from 14 cm up to 36 cm total length (TL) composed the catch of the fishermen during the time of sampling (Table 2). Amongst these, over 99 % of the catch ranged in length between 22 to 34 cm in TL. More importantly the length groups 24 to 34 cm TL composed about 96 % of the total catch (Table 2).

Unlike this focused group discussion with fishermen of the reservoir indicated that decade ago, tilapia measuring up to 36 to 40 cm TL were very common in the fishermen catch and the average catch size of tilapia was 28 to 34 cm TL. This may be the time during when the fishing pressure was quite low.

According to Yosef [2002] [12], the length at first maturity of tilapia about 20 cm TL. In the present result fish below 20 cm composed about 0.36 % of the total catch (Table 2). It was low portion of the fishermen catch composed immature tilapia that have not yet reproduced at least once in their lifespan. The total annual catch of tilapia during the sampled year *(*1-10-2019 to 1-12-2019). was estimated 1,107,106 fish (Table 2).

Table 2: Fish caught during the 60 days of sampling *(*1-10-2019 to 1-12-2019). and estimated total annual catch by length group.

Length group	**Total caught/60 days (number)**	**Estimated annual catch (number)**	**Proportion of length group composition from the total catch (%)**
14-16	29	176	0.016
16-18	31	189	0.017
18-20	46	280	0.025
20-22	60	364	0.033
22-24	7006	42619	3.850
24-26	18076	109962	9.932
26-28	42151	256419	23.161
28-30	51048	310542	28.050
30-32	45108	274407	24.786
32-34	18141	110358	9.968
34 &above	295	1792	0.162
Grand Total	181990	1107106	100

Source: Stock assessment work

3.1.2. Estimates of population number and fishing mortality coefficient by length group of tilapia in Alwero reservoir

Table 3 below gives estimates of population number and fishing mortality coefficient by length group of tilapia that composed the fishery. The estimates are made using John's length based cohort analysis model [John, 1984]. The second column is the total number of fish caught per year in each length group estimated based on catch statistics record. Estimates of population numbers (N(L1)) and Fishing mortality coeffecients (F(L1, L2)) shown by columns 3 and 4, respectively are direct out puts of the Jones length basedcohort analysis.

Over all 37.9 million tilapia population has been estimated to exist in the fished part of the reservior as obtained by summing the population numbers of the respective length groups that composed the fishery given by column 3 (Table 3) As shown by column 4 of Table 3, the length groups 30 to 34 cm fish shouldered heavy fishing mortality rate bearing above 0.5 fishing mortality per year. Although tilapia starting from 14 to 16 cm were recruited to the fishery, most of the fishing pressure relied up on length groups starting 28 cm to 34 cm. As estimated by the model, over 7.6million tilapia of 14 to 16 cm fish are recruited to the fishery every year at the fished part of the reservoir (Table 3).

Table 3: Estimates of population numbers, fishing mortalities and other parameters by Length group. Values are calculated using Jones length based cohort analysis

Length group	**Estimated annual catch (number)**	**Population Number N(L1)**	**Fishing mortality (yr^1)F(L1, L2**
14-16	176	7636704	6.8802E-05
16-18	189	6738499	7.55249E-05
18-20	280	5863667	0.0001
20-22	364	5014179	0.0002
22-24	42619	4192571	0.0190
24-26	109962	3364060	0.0527
26-28	256419	2520736	0.1412
28-30	310542	1622036	0.2243
30-32	274407	813478	0.3420
32-34	110358	230164	0.7778
34 &above	1792	2756	0.6500
Total	1,107,106	37,998,852	

Source : Stock assessment work

3.1.3. Fish yield

Table 4 below gives estimates of total annual yield of tilapia (tons) of the fish. Values in columns 2 are the annual catch of the respective length group fish displayed in previous tables and they are shown here to illustrate the intermediary calculation steps. The mean weight of fish (kg) shown by column 3 are the average weights of each length group of tilapia estimated using the length weight relationship expressed by the following equation [Yosef, 2002] [12]

Wt (gm) = $0.0184 * L^{3.0197}$

The coefficient of determination (R^2) value for the relationship was 0.99 indicating that the estimated total weight for the respective length groups is 99 % valid as the measured length of each length group.

The current total yield pertaining to the respective length group (column 4) was obtained by multiplying the total catch of the respective length group by the corresponding mean weight values. In due regard, the total annual yield of tilapia shown at the bottom of columns 4 (Table 4) are obtained by summing up the yield, respectively of each length group that composed the fishery. The annual total yield of tilapia during the sampled year was 251.07tons/year

FAO [2014] [3] also estimated a total annual yield of 394 tons of fish/year as harvested by the fishermen cooperatives at Alwero reservoir. The estimate in 2010 was about144 tonns/year [Fishery Development Program]. As mentioned earlier, during the time of sampling, the fishermen were fishing at reservior. Therefore the current estimate gives a yield estimate close to 251.07tons/year, which can be an estimate for the whole reservoir area.

Table 4: Estimates of total yield of fish by length group under the current level of fishing effort for the tilapia stock of Alwero reservoir

Length group	Estimated annual catch (number)	Mean weight (kg) W(L1,L2)	Current yield (tons/year) Y(L1,L2
14-16	176	0.05	0.009001
16-18	189	0.07	0.013999
18-20	280	0.09	0.028953
20-22	364	0.13	0.053103
22-24	42619	0.17	8.270122
24-26	109962	0.22	28.77476
26-28	256419	0.27	71.75296
28-30	310542	0.34	87.2666
30-32	274407	0.41	52.65664
32-34	110358	0.50	1.075533
34 &above	1792	0.65	1.17
	Total Yield/year 251.07		

Source: Stock assessment and yield prediction

3.2. Predicting yield obtained from the fishery

3.2.1. Yield predictions under the assumption of doubling rate of fishing effort

Total yield shown in Table 4 was obtained under the current fishing effort level which resulted in fishing mortality shown in column 4 of Table 3. Accordingly, these current fishing mortality rates of the respective length groups were considered as reference fishing mortalities and they were raised and lowered by certain factors (F-factors) to predict yield at the changed level of fishing mortalities. For example, Table 5 below shows results of predictions made under the assumption of doubling of the fishing effort expanded on the tilapia stock of Alwero reservoir. Thus the new F values shown by column 2 (Table 5) are twice the value of the current fishing mortalities shown in column 4 of Table 3. Column 6 shows the mean weight of each length group and the values are same as in column 3 of Table 4. The rest of the columns contain predicted values under the changed fishing mortality levels

Table 5: Output from the length based Thompson and Bell model for the tilapia stock (*Oreochromis niloticus*) from Alwero reservoir predicted based on the assumption of doubling of the current fishing effort

Length group (L1, L2)	Changed F F(L1,L2)	Predicted population N (L1,L2)	Total Mortality D (L1,L2)	Predicted catch/year C (L1,L2)	Mean weight (kg) W(L1,L2)	Predicted Yield (tons/year) Y(L1, L2)
14-16	0.0001376	7636704	991641.8	389.715	0.0462	0.018002
16-18	0.00015105	6645062	962984.8	415.4172	0.0674	0.028
18-20	0.0002309	5682077	931424	614.0724	0.0943	0.057906
20-22	0.00031049	4750653	981809.6	870.2073	0.1276	0.111006
22-24	0.03804134	3768844	1049443	102881.4	0.1679	17.27175
24-26	0.10537235	2719401	1177807	272542.4	0.2159	58.8516
26-28	0.28238109	1541594	951119.4	424709.3	0.2724	115.6971
28-30	0.44858227	590474.6	500959.4	281400.6	0.3380	95.11476
30-32	0.68406164	89515.17	89464.49	59183.34	0.4134	24.46605
32-34	1.55553955	50.68141	50.68141	41.3725	0.4993	0.020656
≥ 34	1.3	0	0	0	0.6493	0
Total						311.6368

Source: Stock assessment and yield prediction

Since a change in fishing mortality obviously results in a change in population number of fish in the water, new estimates of population numbers in each length group were predicted using equation 24 as shown in column 3 of Table 5. Column 4 (Table 5) gives the total number of deaths expected while the fish grow from length L1 to length L2, i.e., D(L1, L2) and this is equal to N(L1) – N(L2). From this total death, the fraction those die due to fishing make up the total catch. Accordingly the catch per length interval (Column 5) corresponding to the changed fishing mortality were calculated by multiplying the values in column 4 by F/ Z , where F and Z are the new fishing and total mortality values corresponding to the changed fishing efforts.

Then the predicted catch in number (values of column 5) were multiplied by the mean weight of each length group (values of column 6) to estimate the expected yield under the changed fishing mortality (column 7).

In due regard, the total yield levels to be expected under the new level of fishing effort are indicated at the lower end (last raw) of Table 5. These values are obtained by summing up the contributions of each length group. This analysis shows that the total yield to be expected from doubling of the fishing effort (i.e., 311.6 tons) is far from the yield obtained at the current level of fishing pressure (i.e., 251.07 tons). Hence the effect of doubling the effort would have a contribution of increment in the total yield obtained from the stock. Therefore doubling the current fishing effort is the total yield obtained increases.

3.2.2. Yield prediction under different levels of fishing efforts

The results summarized in Table 5 are predictions corresponding to a one-time change in the fishing pressure. Such predictions have been evaluated for different values of fishing mortalities so as to see the full spectrum of the effect of changing the fishing effort on the stock. For instance, Table 6 shows summary of yield predicted using values of F-factors ranging from 0 to 2. Predictions were made based on the length based Thompson and Bell model. The reference F array is shown in column 6 of Table 3 It has been multiplied by each value of F-factor shown in column 1 of Table 6 to produce the new fishing mortality coefficient for each length group. Then values of yield were predicted using the new F-array. In due regard, Column 2 show expected values of total yield for each of the F-factors. These values have been obtained after going through the whole procedure of computations illustrated for Table 5. Note that the total yield values corresponding to the F-factor 1 are same as in Table 4 because no change has been done to the reference F-array. Similarly the total yield levels corresponding to the F-factor of 2 in Table 6 are same as in Table 5 and again this is because an F-factor of 2 means doubling of the reference F-array.

Table 6: Values of total annual yield (tons), obtained from tilapia (*Oreochromis niloticus*) stock of Alwero reservoir predicted using values of F-factor ranging from 0 to 2

F-factor	Predicted total annual yield (tons)
0.1	57.8
0.2	98.99
0.3	130.909
0.4	156.86
0.5	178.6
0.6	197.12
0.7	213.09
0.8	226.99
0.9	239.16
1	251.07
1.1	259.41
1.2	267.87
1.3	275.45
1.4	282.25
1.5	288.39
1.6	293.94
1.7	298.98
1.8	303.58
1.9	307.78
2	311.63

Source: Stock assessment and yield prediction

NB. Shaded values refer to the maximum sustainable yield (MSY) as well as to the corresponding optimum level of F-factor.

According to the above analysis, the value of maximum sustainable yield of the tilapia stock is 311.63 tons and this is obtained at an F-factor of 2 (Table 6). This implies that the Lake has a potential for the increment of current level of fishing effort by a factor of 2 to achieve the maximum sustainable yield. This implies that the current level of fishing effort has to be increased by factor of 2 to achieve the maximum yield.

4. Conclusion

According to the results of the study, the reservoir's fishery has different status from biological perspectives. Its biological status could have a potential to produce more. Maximum sustainable yield might be the most desirable equilibrium for a fishery. The maximum sustainable yield of the Alwero reservoir is 311.63tones/yr. The current harvest is estimated at about 251.07tones/yr. Harvesting on Alwero reservoir fishery to its maximum sustainable yield may help in the reduction of the scarcity of fish in relation to its demand. This study has tried to address objectives of the study as: the existing harvest activities of the reservoir.

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