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Assessment of Factors Affecting Nile Tilapia Seed Production and Supply System in Gedeo Zone, Southern Ethiopia

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Abstract

Fish production helps to ensure food security, creates employment opportunities and is a source of income. Even though, fish production is common in our region its production is insufficient. Therefore, this study was conducted to assess and identify major factors affecting fish seed production and supply system in Gedeo Zone, Southern Ethiopia**.** A total of 110 fish producing farmers purposively selected based on fish production practice. The survey was conducted by using structured questionnaires, interview, focus group discussion and personal observations. A cross-sectional survey was used and the collected data was analyzed by using descriptive statistics, inferential statistics and binary logit model. The model indicated that households' participation in fish production is determined by various factors namely shortage of fish seed, fish feed, poor transportation of fingerling and low extension service, these factors had statistically significant effect on households' participation in fish production. Majority (58%) of the respondents were men with age ranging from 25 to 72 years. The average experience of fishing was 5 years. The result showed that 18% of the respondents have got training on fish production. The result has also shown 75% of the respondent was engaged in earthen pond fishing practice, 79% respondents produce fish on their own pond, 12% on public pond and the remaining newly established ponds. Fishing in the study area was carried out occasionally using local materials. Lack of fishing seed, fingerlings transport problems and fish feed were the top three ranked constraints. In general, fish production in the study area was characterized by low inputs and low production of fish. Since the research is being conducted on fish producer farmers, farmers training center, school fish production and most of the farmers have the desire to produce fish. Therefore, in addition to training and extension service the responsibly bodies shall provide fish seeds and feed.

Keywords: Fish, Fish Feed, Fishing Practice, Fish Production, Fish Seed

Background and Justification

Fisheries and aquaculture sector is one of the most important sources of food globally. According to the Food and Agriculture Organization (FAO) (2020), about 179 million metric tons of fish were produced in 2018, of which more than 87% (156 million metric tons) were used for human consumption, making food fish one of the most important sources of animal protein globally. Per capita fish consumption has increased consistently from 9 kg (live weight equivalent) in 1961 to 20.5 kg in 2018 (FAO 2020).

Beyond the supply of food, the capture fisheries and aquaculture sector is also a key source of livelihood. In 2018, the sector is estimated to have employed 59.51 million people, of which about 85% were employed in Asia (FAO 2020). Filipski and Belton (2018) [7] were able to determine that "aquaculture generates much higher incomes per-acre than agriculture and generates larger income spillovers than agriculture for non-farm households by way of retail and labor markets." Thus, aquaculture can be very effective in reducing poverty and increasing rural incomes. The proportion of global food fish from aquaculture has increased from less than 10% five decades ago to approximately 52% in 2018 (FAO 2020).

Africa accounts for approximately 2.7% of global aquaculture production. The value of this production is equivalent to only 1.3% of total global value (FAO 2020). Sub-Saharan Africa accounted for only 0.75% of aquaculture production in 2014 (FAO 2016) [8]. Nevertheless, production increased seven-fold over a period of 10 years, from 80,900 t in 2004 to 556,950 t in 2014, representing an annual increase of 21%. About 90% of Africa's aquaculture output is produced by Egypt, Nigeria and Uganda

(Adeleke *et al*., 2020) [1]. However, this growth has hardly kept pace with population growth and demand for fish, with consumption dropping from 10.5 kg in 2014 to 9.9 kg in 2017 (Brummett 2007 [3]; FAO 2020).

In Africa, low fish seed supply has persisted despite huge capital investment into hatcheries from foreign donors and governments (Musyoka and Mutia 2016) [17]. Fish seed supply in Africa is erratic and unreliable, such that farmers are unable to access the required quantity or the right quality when and where they need them. Improved breeding can increase aquaculture yield by 5.6% to 49%, depending on the species of fish and type of improvements (Li *et al*., 2021) [14], an indication of the production losses fish farmers in Africa incur when they do not grow improved breeds.

Like all other agriculture and food production sectors, the availability of seeds of the right quality, as and when needed, is a key prerequisite for production (Kramer and Galiè 2020) [13]. Seed supply systems can be used to deliver productivity, gender equity, nutrition and climate adaptation to farmers of all sectors (Thomas 2008; McGuire and Sperlin 2013; Shikuku *et al*., 2019) [21, 16, 18]. An assessment of the effect of access to quality fish seed showed an improvement in welfare indicators for households, including food security status (Shikuku *et al*., 2019) [18].

In Ethiopia fish production depend on the inland waters for the supply of fish as a cheap source of animal protein. It can also indirectly contribute by providing revenue for purchasing food for deficient areas (Dawit *et al*., 2013) [4]. The country has a different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems, including river basins, major lakes, many swamps, floodplains and man-made reservoirs. The fish supply in most cases comes from the major lakes and some reservoirs such as Fincha, Hawassa, Tana, Chamo, Ziway, Koka, Abaya, and rivers in the country.

Ethiopian lakes, is mainly practiced, are threatened by poor production system with catchment's deforestation (shore damage), water pollution and siltation, overfishing, habitat destruction, invasion of non-native species, illegal, unregulated fishing, and poor governance (Hecky *et al*., 2010; Dereje, 2014) [11, 5] and it is far below its potential (Kebede *et al*., 2017) [12]. Improvements in fishery sector highly contribute to sustaining livelihood of rural fishing community and ensure environmental sustainability in Ethiopia.

Various innovations and technologies have improved the quality of fish seed in use, as well as the resulting productivity. For example, the invention of the Genetically Improved Farmed Tilapia (GIFT) technology to produce monosex (all male) fry has considerably increased the production of tilapia species in many Asian countries (Alam *et al*. 2019; Shikuku *et al*. 2021) [2, 19].

Despite the fundamental role of fish seed systems in the aquaculture sector, and the evident poor performance of the seed sector, fish seed systems are poorly documented and the literature on them is scant. Therefore, the strategies to improve the quality of fish seed production, multiplication and distribution under different conditions are highly needed. The study therefore aims to assess the fish seed production problems and improve the multiplication and distribution at selected district of Gedeo zones, Southern Ethiopia.

Objectives

- To assess major factors affecting fish seed production at Gedeo zone.
- To identify opportunity and challenge of Nile tilapia seed production in the study area.

Materials and methods

The Survey was conducted in Gedeo zone. Two district and three kebeles were selected purposively based on fish production practice. The activity was composed of survey work on constraint identification.

Types and Sources of Data

The data was collected from primary and secondary sources. Primary sources of data was questionnaires, focus group discussion and key informant interviews. The required secondary data was collected from regional, zonal and woreda level of Agriculture and Natural Resource Bureau, published and unpublished reports, journals, books, websites, and other sources relevant in this study.

Sampling method

In this study multistage sampling technique was used. In the 1st stage, from Gedeo Zones potential woredas was purposively selected based on the secondary information obtained on fish production and seed demand. In the 2nd stage, from the selected woredas', kebeles were selected.

In the 3rd stage, fish farmers and their neighbors were selected based on their interest to expand their fish farming existing practice and also to start new production in collaboration with Agricultural rural development expert.

Method of Sample size determination

The Sample size was determined as Yemane (1973) [22]:-

$$n = \frac{N}{1+N(e)^2} \quad n = 150/1+150(0.05)^2 \quad n = 150/1.375 = 110$$

Where, 150 total earthen pond using farmers

Where;

n = Sample size required
N = The population in the study area
e = error (0.05) reliability level 95%
or; *e* = level of precision always set the value of 0.05.

Method of Data collection

The data was collected using the questionnaires focused on the current status of tilapia farming practice, focus group discussion and key informant interview. The existing major constraints on access to quality fish seed, way of obtaining fish seed, and possible intervention solutions to the existing fish seed related problems.

Methods of Data Analysis

The data was analyzed by using a combination of descriptive statistics, inferential statistics and logistic regression model. In the study the logit model based on cumulative logistic probability function were employed. In line with, Maddala (1983), Green (1991), Gujarati (1995) the logistic distribution function for the production of fish seed can be specified as:

$$P = \frac{1}{(1+e^{-zi})} = \frac{e^{zi}}{(1+e^{zi})} \quad (1)$$

Where Pi - is a probability of production of Nile Tilapia fish seed for the i^{th} farmer and it ranges from 0-1. P is the observed response of the i^{th} farmer (i.e., the binary variable, P = 1 for a producer, P = 0 for a non-producer), e^{zi} -stands for the irrational numbers e to the power of z_i and z_i - is a function of n- explanatory variables (X_i) which is also expressed as:-

$$Zi = \beta 0 + \sum_{i=0}^{n} \beta iXi + Ut$$

Z is underlying and unobserved stimulus index for the i^{th} farmer, i = 1, 2,…. n, are observations on variables for the production model, n being the number of explanatory variables in this study represents 10 independent variables, βo = an intercept, βi = unknown parameters to be estimated (Coefficients of i^{th} independent variable), Xi = independent variable and can be either dummy or continuous, i runs from 1-10, Ut = unobserved disturbance term. The slope tells how the log odds ratio in favor of production of Nile Tilapia fish seed changes as independent variable change. If pi is the probability of production of Nile Tilapia fish seed then 1- pi represents the probability of not producing it.

$$1 - p = 1 - \frac{e^{zi}}{(1 + e^{zi})}$$
$$= \frac{e^{zi}}{(1+e^{-zi})} = \frac{1}{(1+e^{zi})} \quad (2)$$

Thus, the odds ratio can be written as

$$\frac{\text{Pi}}{1-\text{Pi}} = \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} \quad (3)$$

Therefore, $\frac{\text{Pi}}{1-\text{Pi}}$ is the odd ratio in favor of producing Nile Tilapia fish seed. Likewise, it is the ratio in favor of probability that the farmer would produce Nile Tilapia fish seed to the probability that the farmer will not produce. Eventually, taking the natural log equation:

$$li = \ln\left(\frac{\text{Pi}}{1-\text{Pi}}\right) = (\ln e^{\beta 0} + \textstyle\sum_{i=0}^{n} \beta iXi + Ut) = Zi = \beta 0 + \sum_{i=0}^{n} \beta iXi + Ut \quad (4)$$

Where Li = is log of the odds ratio in favor of Nile Tilapia fish seed production, which is not only linear in X_i but also linear in the parameter. This model can be estimated using the iterative maximum likelihood (ML) estimation procedure. In reality, the significant explanatory variables do not have the same level of effect on the production decision of farmers. The comparative effect of a given quantitative explanatory variable on the production decision is measured by examining production elasticity. The variables that were assumed to influence the production decision of Nile Tilapia fish seed were tested for multicollinearity. Multi-collinearity test between continuous and discrete explanatory variables was done using variance inflation factor (VIF) and contingency coefficient (CC), respectively. The highest VIF (1.43) and CC (0.0913) values were below the maximum.

Table 1: Continuous and discrete dummy explanatory variable with their unit and expected sign

Code	Explanatory variable	Unit	Hypothesis
Sex	Sex of the respondent (1=male, 0=Female)	Dummy	+(male)
Age	Age of respondent	Year	+
Education	Education level of respondent	Year	+
Family size	Family size of the respondent	Count	+
Credit	Access to credit (1=access 0=no access)	Dummy	+
Market transport	Distance to the nearest market Center	Meter	-
Fish experience	Fish production experience	Count	+
Extension	Respondent extension contact (1=Yes 0=No)	Dummy	+
Fish seed	Availability of fish Seed	Dummy	+
Fish feed	Availability of fish Feed	Dummy	+

Result and discussion

This result describes the demographic and socio-economic characteristics of respondents. The survey was conducted with 110 respondents. The socioeconomics characteristics of the respondents included in the current study are represent in Table 2.

Table 2: Demographic and socio-economics characteristics of Respondent

Descriptive Statistics of demographic and socio-economics characteristic					
Variable	N	Min.	Max.	Mean	Std. Dev.
age	110	25.00	72.00	47.09	10.56005
family size	110	1.00	9.00	5.73	.98931
Educational	110	2.00	12.00	6.61	2.66852
Fishing experience	110	2.00	9.00	4.82	1.57886

Source: Result of own survey

The mean age of respondents was 47 years with the minimum and maximum age of 25 and 72 years, respectively. The mean experience of fishing was 5 year with minimum 2 and maximum 9 years. The mean education level was 7 with minimum and maximum value of 2 and 12, respectively. The mean value of respondents' family size was 6 persons with the minimum and maximum 1 and 9, respectively. The percentages, given in all the results of this study, indicate the percentages of the respondents interviewed, unless otherwise stated.

Table 3: Description of the categorical variables across fishing farmers

Variables		Frequency	Percent
sex	Male	64	58
	female	46	42
Marital status	Married	106	96
	Single	4	4
Access to training	Yes	18	13
	No	92	87
Access to credit	Yes	40	36
	No	70	64
Access to extension Service	Yes	40	36
	No	70	64
Access to market information	Yes	22	20
	No	88	80
Awareness of fish production	Yes	37	34
	No	73	66

Source: Result of own survey

The survey result indicates majority the respondents in study area were men. It indicates that fishing activities were male dominated. About 18% of respondents got training services. Only 36% of the respondents accessed credit. Access to extension services diversifies other agricultural activities other than fishing. The summary statistics shows that, 36% respondents got extension services. Thus, only 20% of respondents accessed market information. Majority 66% of respondent have no awareness of fish production. Awareness depends on knowhow on fish production.

Status of Household participation in Fish production practice

In the study area the survey results showed that majority of the respondents participate in fish farming practice. According to the focus group discussion and key informant discussions, the fishing practice in the area previously kwon but monitoring and follow up exercise continued by extension support farmers on fish production.

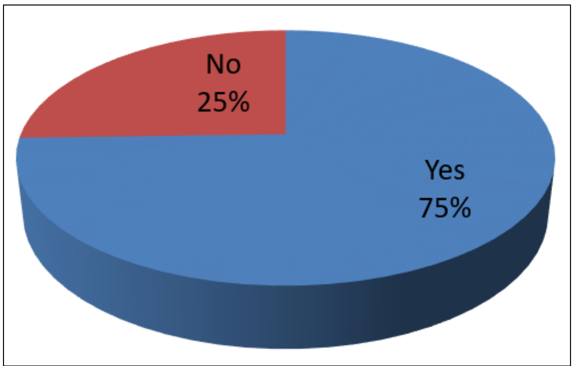

Fig 1: Fish engaging frequency

Fish production almost all of the constructed fish ponds in the study were earthen pond. Of the surveyed fish ponds, the majority (79%) were own pond, 12 % of fish pond found on public (school and farmers training center) and the remaining 9% were new established pond. The result shows that earthen ponds were more common in the study area than other type of ponds. A study similarly by Erkie *et al.* (2019) [6] recommended earthen ponds as a means to ensure maximum utilization of pond resources and increasing production. The water sources for the ponds come from rivers. Based on the agro ecology of the study area, almost all of the ponds were stocked by Nile Tilapia fish seed. In the mid- highland or temperate area of the area, Nile Tilapia is the main fish species preferred and recommended for fish production.

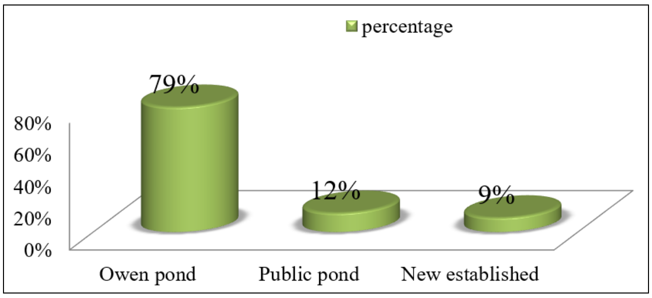

Fig 2: Fish pond percentage

Damaged fish pond on the study area

The observing and follow up on the progress of fish farming is not past stocking ponds by fingerlings. However, the exercises begin from pond development to utilization and marketing are cleared out for farmers who don't have any viable information about fish farming. Due to these issues, farmers have stopped the pond management to the degree that the ponds ended up secured with grass and residue (Fig 3). Due to this, public ponds in Abiyot fire and Haru farmers training center use their pond's earthen ponds not delivered completely. In addition, most of the experts more closed for crop and livestock related activities, however, in the extension system, fishers has less consideration. These capacities relate with the experts' information crevice approximately fisheries related issues. There was too an sign from the field day that agriculturists (not completely fish producers who were welcomed to visit fish ponds) were astounded when they saw fishes within in the ponds since they as it were know that fish can survive as it were in lakes and rivers and not in ponds.

A. Abiyot Fire School B. Haru FTC

Fig 3: Fish pond covered with grass

The district level fishery experts themselves seem not getting a hands-on training. As a result, these fishery experts might not be able in giving technical supports for the fish farmers. In expansion, districts' fishery experts don't involve through the full strategies of show inquires about and this prevents them from overhauling themselves.

Pond management in the study area

In the study area most of the farmers frequently observer the overall performance of their ponds. Because of these, farmers do not know whether there is market sized fish in their ponds or not. On the other hand, some ponds are direct sunlight due to the shades of trees and their branches around the ponds (Fig 4). In addition, there are ponds that are complete of grass and siltation during runoff. According to the focus group discussion and key informant discussions, good pond management is the contributing primarily of fish production in the area. Based on the level of input used and the degree of management, the current fishing practice of the area reduced towards extensive type. Such extensive type fishing practices are known for their respectable pond management consequently insignificant returns.

A. Water reservoir (Mr. Teshome G/m) Y/chefe Qonga Kebele
B. Fish farming Pond

Fig 4: Fish pond water reservoir and fish farming

Fish harvesting time

According to the respondent, 37% fishing activity were done at any time, 25 % of the respondent harvested occasionally. 13% the respondent harvested at drought season and the remaining respondents do not start to harvest fish. Fishing in the study area is mainly dependent on wild capture with no support from aquaculture activities. According to the response obtained from the focus group discussion, fish was captured during at different times. According to respondent large amount of fishes were harvested continuously at any time.

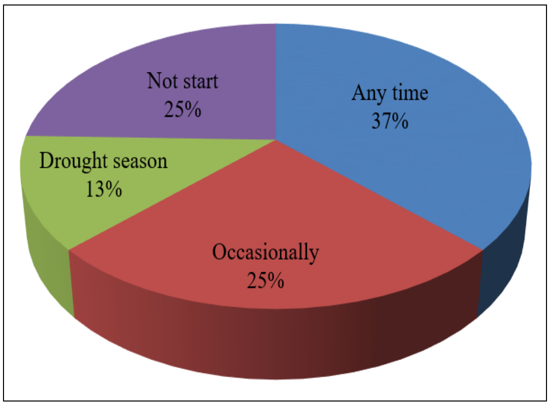

Fig 5: Time of fishing activity

Purpose of fishing

Fisheries can provide year round production and income for households especially when crop production is strained due to irregular rainfall or factors beyond national control. Fish is the rich source of protein with an amino acid composition very well suited to human dietary requirements comparing kindly with eggs, milk & meat in the nutritional value of its protein. The survey result indicated that, majority of respondents 94% and 6% of the pond owners to harvest fish for home consumption and income generation respectively. According to the respondent, almost all farmers used fish for home consumption and few farmers income generation. In the study area, almost all of the farmers initially aimed to consuming them at home than harvested fish their sell. The lack of any fish markets, farmers become forced to harvest their fish for home consumption. However, these farmers have lack knowledge about fish handling.

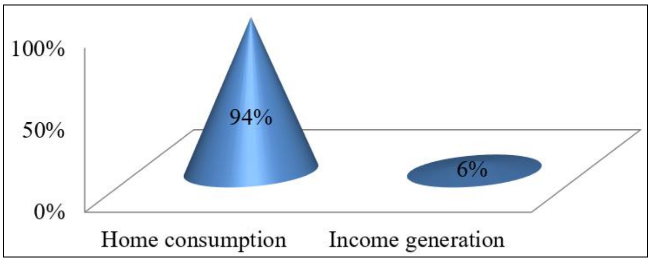

Fig 6: Importance of fish farming in the study area

The Household lag behind from fish production

45% no awareness about fishing, 40% shortage of fish feed and 15% Shortage of alternative fish species (other fish seeds like Catfish and Carp). In general majority of 91% respondent have interest to continue in participating in fish production in the future.

Constraint and opportunity of fish production

Constraints

The survey result indicated that the listed and ranked the different constraints for fish production in the study area as presented in Table 4. Lack of fish seed and transfer problem was found at the first and second constraint of fish production with its index 0.154 and 0.148 respectively. So, provisions of heath fish which adopt to the study area environment and with appropriate prices were crucial actions. The third and fourth ranked constraint of fish production was lack of fish feed and lack of training. In order to increase fish production provision of improved fish feed and training facilities necessary for farmers in the study area.

Table 4: Major constraints for fish production in the study area

Constraints of fish production	Rank									
	1st	2nd	3rd	4th	5th	6th	7th	Weight	Index	Rank
Fish seed	29	21	17	13	11	10	9	528	0.154	1
Fingerlings transfer problem	26	20	15	12	18	11	8	509	0.148	2
Fish feed	24	18	14	16	15	12	11	490	0.143	3
Land shortage	21	18	15	17	14	13	12	478	0.139	5
Lack of multiplication center	20	17	18	16	13	15	11	476	0.138	6
Lack of training	24	18	15	15	11	14	13	485	0.141	4
Lack of institutional support	20	17	14	16	15	13	15	462	0.135	7

Econometric model factor affecting fish production

Moreover, the chi-square value is significant at less than 1% significance level. This indicates that the overall significance of the model is good. The coefficients, statistical tests and marginal effects of each independent variable are presented under Table 5. The model result shown that four variables were statistically significant at less than 1% significance level. These variables were fish experience, extension service, fish seed and fish feed.

Table 5: Logit Estimate of factor affecting fish production

Production fish	Coefficient	Standard error	z	P> lzl
Sex	0.1593	0.4858	0.33	0.743
Age	0.0007	0.0291	0.02	0.981
Education	-0.0324	0.0981	-0.33	0.741
Family size	0.1048	0.1263	0.83	0.407
Credit	0.3222	0.4883	0.66	0.509
Market transport	0.3861	0.4868	0.79	0.428
Fish experience	0.5136	0.1761	2.92	0.004***
Extension	1.1642	0.5649	2.06	0.039**
Fish seed	2.0363	0.7644	2.66	0.008***
Fish feed	1.4105	0.6730	2.10	0.036**
_cons	-4.0664	1.9269	-2.11	0.035

Logistic regression Number of obs. = 110
LR chi2 (10) = 27.09
Prob > chi2 = 0.0019
Log likelihood = -58.1513 Pseudo R2 = 0.1935

Opportunity for fish production

There's an opportunity to maximize the fish production within the think about zone because there's tall request for fish within the region. Comparable report appeared that the request for fishes is expanding twofold in Ethiopia (Mathewos and Abebe, 2016) [15]. Moreover, there are no regular and religious impacts on fish utilization design and accessibility of water through the year. The specified opportunities may increase the income of fish farmers when they will provide an accentuation to improve the productivity. Increasing number of fish farmers to misuse the fish potential of the pond is important to increase the income of the society. Similarly, the current production in area is still distant underneath the assessed potential abdicates, which suggests scope for further expansion of the fishery (Tesfaye and Wolff, 2014) [20]. In this way, fishery and aquaculture in Ethiopian is recognized as an alternative implies of accomplishing nourishment security in specific and destitution decrease in common, and is presently considered as a fundamentally portion of provincial and agrarian advancement techniques (Kebede *et al*., 2017) [12].

Conclusion

The study showed that among the participants households 75% started to grow and use fish, and the rest had a partial pond due to lack of awareness and did not start using it. Among those who participate in fish production, 79% of respondents were produce fish in their own pond and 12% in schools and farmer training center.

The main challenges raised by the participants in relation to fish production is the problem of adequate supply of fish seed for fish producer farmer is important, The research indicated that the fingerlings died after they have arrived at the farmers and were added to the pond due to the mistreatment during the transportation.

Farmers uses traditional feed as a result, the fish do not reach production at the right time because they fed on non-concentrated feed. In addition, personal observation, on the fish pond at the school and the farmer's training center was filled with silt and grass, and as a result, it could not serve for fish production.

Recommendations

- Based on the finding, the relevant stakeholder's area should participate and provide the necessary input such as fish seed for fish production.
- Farmers involved in fish farming should be given adequate awareness training.
- The distribution of fingerlings shall be done based on the local climate and needs of the farmers.
- Providing improved fish feeds that increase fish productivity are important to the farmers at affordable prices.
- The market linkage and transport mode need to be convenient for the farmers who are engaged in fish production.

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