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Survey of Factors Affecting the Sustenance and Productivity of Tropical Streams and Ponds in Madagali Local Government Area, Adamawa State

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Abstract: *The investigation involved identification and inventory of streams, ponds and fish species. It assessed the water volumes, fish productivity, factors affecting fish productivity and management strategies currently in use for the water bodies and those suggested for ameliorating the situation. The study identified 8 Streams and 4 Ponds. Result of assessment of water volumes showed that Shuwa stream with 132,225.0m^3 was highest and the least was Giwa Mblaji (5,514.25m^3). In terms of lost water volume, Shuwa (66,112.50m^3) was also highest and the least was Giwa Mblaji (3,151.0m^3). For Ponds, the water volume of Zhau (111,102.36m^3) was highest. 13 fish species belonging to 6 families were recorded across the water bodies. Result of fish productivity showed Kwajiti (3.962kg) as the highest and least was Dzuel (2,395kg). Based on fish species, Clarias gariepinus (4,795kg), Clarias lazera (3,863kg) and Tilapia zilli (2,047kg) were the top reproductive fish species. Factors affecting the sustenance, and fish productivity of Streams and Ponds in perceived order of endangerment based on worst and worse effects showed;* poor fishing practices characterized by partitioning of streams into paddocks and total draining of water mostly using the water power pumping machine (29.17% and 27.50%) and *agricultural expansion (24.17% and 48.33%) are the leading threatening factors. Based on strongly agreed the study suggested; adoption of restoration process of water bodies through controlled fishing (45.0%), provision of alternative fish source to divert people's attention from stream and pond overexploitation (40.0%) and provision of buffer zones between farming sites and water bodies to aid bank consolidation (39.17%) among others could be adequate if effectively utilized for addressing the factors threatening the sustenance of tropical streams and ponds.*

Keywords: Fish species, sustenance, productivity, strategies, water volumes, factors

INTRODUCTION

Nigeria's rural communities are faced with numerous challenges but none is more significant than lack of access to adequate protein supply being a key in human survival. The effort of most citizenry today to ensure that such commodity is made available and affordable is encountering setbacks because of the increasing human population. The inability of the low- and middle-income earners to access adequate animal protein has resulted to unprecedented desire for fish protein because of its relative affordability which encourages patronage by the low- and middle-class income earners segment of the society.

In most rural communities, human population continuous to grow but the animal protein supply is constantly on the decrease and a rise in the prices of the commodity at a rate mostly not affordable by the greater part of the society especially the rural dwellers. According to Have *et al*. (2020), this situation most a times transforms into a disaster that threatens existence of a healthy community. Raminez *et al*. (2018) stressed that increased stream and pond fish production could guarantee supply of fish protein at low-cost to help improve the situation thereby averting the perceived danger of poor nutrition on the human population. On scale of assessment, streams and ponds are among the most valuable assets that must be protected by man in order to guarantee his survival hence the need to protect them cannot be debated (Piffer *et al*., 2021).

Although the categorical statement made by Piffer *et al*. (2021) above is fundamental but the low economic status of the majority of the local residents of different communities of Madagali local government area of Adamawa State made them relay almost solely on fish protein, thereby abusing the idea of protection of natural water bodies. The majority of the local residents cannot afford beef, mutton, pork etc. because they are mostly low-income earner segment of the society. Adams (2018) emphasized that streams provide 70-80% of fish consumed in most rural areas making the resource overexploitation inevitable by the local residents. In line, McIntyne *et al*. (2016) stressed that the importance of stream water fisheries as food for all segments of the human society cannot be over stated and not arguable.

According to Ndasaya (2021) the threat to sustenance of streams and ponds in Madagali local government area can be linked to the people's engagement in fishing and fishery business and that 10 - 15% of the local residents actively participating in small scale irrigation farming. The overdependence on the tropical streams and ponds for fishing in most rural communities of Adamawa state had led to overexploitation of the resources thereby causing decrease in the volume of the water bodies while others are at the point of extinction, a situation that could be linked to poor fishing practices (Linus *et al*., 2014).

Human careless exploitation of this resource tend to threaten its continuous existence making the resources associated with streams and ponds stand on the balance. This perceived problem could be an obstacle to conservation, protection and management of streams and ponds in attempts to preserve the environment, and to ensure the sustainability and the natural food chain inclusive of man (Vysochyna *et al*., 2020).

To achieve the human desire for stream and pond sustainability and restoration, it is important that an enabling environment be provided through a well-designed institutional framework and management instruments for the water bodies so as to enhance productivity in both fauna and flora. Man, who is saddled with the responsibility of providing information on how institutional framework could be developed for sustenance and increased productivity of the streams and ponds has vehemently become unfriendly to the environment, thereby putting his survival at risk.This study has provided an insight on the abuse of the natural water bodies and how it can be controlled and managed for sustainability and increased productivity through; identification and documentation of the most utilizable streams and ponds in Madagali local government area of Adamawa state, assessment of the water volumes of the streams and ponds, fish productivity of the streams and ponds from 2022 – 2024 and the factors affecting the sustenance of streams and ponds in the study area. Similarly, the investigation has developed management strategies that could be adequate for the sustenance of streams and ponds to guarantee improved fish productivity and other associated resources.

MATERIALS AND METHODS

Study Area

The study was conducted in Madagali local government area of Adamawa state, Nigeria, which shares a boundary with Gwoza local government area of Borno State in the North, Askira Uba local government area of Borno State in the West, Michika local government area of Adamawa State in the South and Cameroon Republic in the East. The local government area lies on latitude 10^{o} 24^{1} N and longitude 13^{o} 48^{1} E with a population of 156, 230 (National Population Commission, NPC, 2016). Below (**Fig. 1**) map of Adamawa state showing the study area.

Figure 1. Map of Adamawa State Showing the Study Area
Source: Adebayo, 1999

Materials and Items Required
For effective conduct of the investigation, the following materials/items were used; boot, survey hand gloves, binocular telescope, 100m tape, structured and unstructured questionnaire, depth measurement range, current meter, standard fishing net, machete, digger, survey umbrella, freshwater fish species manual and research recording books etc.

Data Collection
The study area was crisscrossed for identification and documentation of existing streams and ponds. It also effectively utilized the map of Madagali local government area to ease data collection process. In line, the reconnaissance survey involved interaction with the most popular fishers and fish vendors (traders) that helped in easy location of the water bodies and the sampling of the respondents (the fishers).

Standard method as adopted by Enerijiofi (2018) was used for the assessment of water volume of each stream. Mathematically, given as;
Volume of Stream Water (VSW) = L x W x D (0.25 x depth of stream) x 7.48
Where;

L = length
W = width

D = depth of stream
7.48 = is a standard

Similarly, the volume of water in each pond was calculated based on the method adopted by Dappa (2020), mathematically given as;
Volume of Pond Water (VPW) = AL x AW x AWD x 7.48
Where;

AL = average length
AW = average width
AWD = average water depth
7.48 = is a standard

The investigation also assessed the lost water volume of streams and ponds using the modified method of Cohen (2019). Mathematically calculated as;

Lost Volume (LV) = $E_{vol} - R_{vol}$ Where;

E_{vol} = expected volume
R_{vol} = realized volume
LV = lost volume

The fish productivity of the streams and ponds for three years (2022, 2023 and 2024) and the factors affecting the sustenance and productivity of streams and ponds as well as the management strategies in place and those that could be employed for enhance productivity of the natural water bodies were sourced through respondents.

Structured and unstructured questionnaires alongside interview schedule were administered on 120 respondents (Table 1) sampled from the following communities; Kwajiti (24), Pallam (31), Dzuel (19), Birishishiwa (26) and Kwakwahu (20) who were of 35 years and above consisting of fishers, fish vendors/traders and those that doubles irrigation with fishing using simple random sampling technique as outlined by West (2016).

The age bracket was to ensure that only respondents actively involved in the fishing activity at least for ten (10) years who were expected to have gotten enough experience on the happenings with regard to fishing were sampled. In addition, Interview and group discussions were held with community leaders and other stakeholders through participatory rural appraisal technique as adopted by Wati *et al*. (2020).

The interaction alongside with on the spot assessment aided in the proper identification, judgment and assessing of the factors affecting the sustenance and productivity of the streams and ponds. The sampling adhered strictly to Kareem *et al*. (2015) method of proportional allocation technique with slight modifications, where **nh** was replaced by **M** and **Nh** replaced by **h**. The formula is stated as follows;

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$$M = \frac{h \times n}{N}$$

Where;
M = number of questionnaire administered in each community
n = total number of questionnaire administered
h = Estimated population of the people in each community
N = total number of people in all the communities

Below (Table 1) is the detail number of respondents drawn from each administrative unit/community on which questionnaire was administered.

Table 1: **Number of respondents per community on which questionnaire and Interview was administered**

Name of community	Population from which respondents were sampled (h)	Number of questionnaire administered in each community (M)	Percentage (%) of respondents in each community
Kwajiti	348	24	6.90
Pallam	436	31	7.11
Dzuel	272	19	6.99
Birishishiwa	364	26	6.94
Kwakwahu	288	20	6.94
Total	**1,708 (N)**	**120 (n)**	

Prevalence Threat Factor Index (PTI) was calculated using the method of Tesema *et al*. (2022) of assessing the severity of threat factors. Mathematically stated as;

$$PTI = \frac{n \times 100}{N}$$

Where;
n = number of respondents mentioning that particular threat factor
N = number of respondents sampled

In line, the validity of suggested threat factors based on respondents' reactions were ranked based on Venter *et al*. (2016) of mark ranking technique (1– 5). Where; No effect (1), Fair effect (2), Bad effect (3), Worse effect (4) and Worst effect (5). Similarly, the assessment of the factors affecting the sustenance and productivity of tropical streams and ponds, management strategies in place and the suggested strategies that could help in the sustenance and productivity of the water bodies was carried out using Likert scale of strongly agreed, agreed, disagreed, strongly disagreed and undecided as outlined by Kusmaryono *et al*. (2022).

The Smith Saliency model was also used for the presentation of fish productivity, management strategies in use and the proffered management strategies for the sustenance and productivity of the streams and ponds. The model is used to calculate the importance of items in a list based on how participants organize them. In this context, the value of the model is calculated by dividing the frequency of respondents in agreement with a factor by all the respondents sampled. Mathematically given as:

$$S = \frac{IR}{TR}$$

Where S = Saliency value
IR = Inverted rank (frequency of respondents in agreement with a factor)
TR = Total rank (total frequency of respondents sampled)

RESULTS AND DISCUSSION

The study identified 8 streams and 4 ponds that are productive in terms of fish resources in the study area as presented in Table 2 below. The water bodies were located across the different communities investigated.

Table 2: **Streams and Ponds and their Locations**

S/No.	Name of water body	Location (communities)
	Streams	
1.	Kauye	Kwajiti
2.	Birishishiwa	Birishishiwa
3.	Galamdu	Pallam
4.	Kofor	Dzuel
5.	Gari	Pallam
6.	Imigu Haman	Dzuel
7.	Shuwa	Kwakwahu
8.	Giwa Mblaji	Kwakwahu
	Ponds	
1.	Mithildil	Birishishiwa
2.	Evali	Pallam
3.	Zhau	Dzuel
4.	Vami	Dzuel

Source: Field Survey (2024)

Assessment of Water Volume of Stream

The assessment of the water volume of 8 streams located in different communities is presented below in Table 3. The result showed that the Shuwa stream (132,225.0m^3) has the highest volume of water and distantly followed by Birishishiwa with 18,065.25m^3 while the streams with relatively low volumes of water were Giwa Mblaji (5,514.25m^3 and Imigu Haman (5,596.50m^3) located in Kwakwahu and Dzuel communities respectively.

Table 3: **Assessment of Water Volume of Stream**

S/No.	Name of water body	Location	Length (m)	Width (m)	Depth (m) (0.25 x water depth) x 7.48	Water volume of stream (m^3) (L x W x WD)
1.	Kauye	Kwajiti	3,100	25.9	0.225	18,065.25
2.	Birishishiwa	Birishishiwa	2,500	36.5	0.275	25,093.75
3.	Galamdu	Pallam	2,900	19.8	0.250	14,355.0
4.	Kofor	Dzuel	3,200	12.6	0,200	8,064.0
5.	Gari	Pallam	2,800	16.8	0.225	10,584.0
6.	Imigu Haman	Dzuel	2,600	12.3	0.175	5,596.50
7.	Shuwa	Kwakwahu	4,100	215	0.15	132,225.0
8.	Giwa Mblaji	Kwakwahu	2,300	13.7	0.175	5,514.25

Key: L = Length W = Width D = Water depth 7.48 = Standard
Source: Field Survey (2024)

Assessment of Lost Water Volume of Stream

For the lost water volume as presented in Table 4, Shuwa (66,112.50m^3) was highest followed by Kauye (14,050.75m^3) and the least was Kofor stream with 2,016.0m^3). The result in Table 4 indicates that the higher the expected volume of stream, the higher the lost volume of water. This scenario could be attributed to the stream flow and possibly the rate of patronage by fishers.

The outcome of this investigation agrees with that of Mangi (2024) and Zidni *et al*. (2019) who reported that most a times the higher the water quality the more the volume of water in streams that could help in making fish productivity better. It is then obvious that the better the fish productivity of a stream, the higher the patronage which could affect stream retention of its water volume. This finding shows that fish productivity is determined by the water volume and its quality as some of the factors guaranteeing the sustenance of streams productivity.

Assessment based on expected and realized volumes using percentages (Table 3) showed a twist in the result of the lost volume of water as Kauye Stream (43.75%), Imigu Haman Stream (41.67%) and Gari Stream (40%) were relatively higher than Shuwa Stream (33.33%) despite that the expected (198,337m^3) and realized (132,225m^3) volumes of water in Shuwa Stream was far more than Kauye, Imigu Haman and Gari Streams put together. The higher percentage volume of water lost for Kauye, Imigu Haman and Gari Streams may likely be due to unsustainable fishing practices characterized by dividing the stream flow into paddocks to trap fish, followed by total draining of the water for easy fish catch.

Table 4: **Assessment of Lost Water Volume of Stream**

S/No.	Name of water body	Location	E_{vol} (m^3)	R_{vol} (m^3)	L_{vol} (E_{vol} - R_{vol}) m^3	Percentage (%) of lost water volume of stream
1.	Kauye	Kwajiti	32,116.00	18,065.25	14,050.75	43.75
2.	Birishishiwa	Birishishiwa	29,656.25	25,093.75	4,562.50	15.38
3.	Galamdu	Pallam	20,097.00	14,355.0	5,742.0	28.57
4.	Kofor	Dzuel	10,080.0	8,064.0	2,016.00	20.0
5.	Gari	Pallam	17,640.0	1o,584.0	7,056.0	40.0
6.	Imigu Haman	Dzuel	9,594.0	5,596.50	3,997.50	41.67
7.	Shuwa	Kwakwahu	198,337.0	132,225.0	66,112.50	33.33
8.	Giwa Mblaji	Kwakwahu	8,663.25	5,514.25	3,151.00	36.35

Key: E_{vol} = Expected volume R_{vol} = Realized volume L_{vol} = Lost volume
Source: Field Survey (2024)

Assessment of Water Volume of Pond

The result of assessment of water volume of 4 ponds investigated (Table 5) showed that Zhau pond (111,102.36m^3) was the highest while others ranged from 12,352.88m^3) for Mithidil to 19,940.52m^3 for Evali. This result indicated that the longer the length of ponds the more the volume of water as shown by Evali and Zhau ponds respectively.

Table 5: **Assessment of Water Volume of Pond**

S/No.	Name of water body	Location	Average length (m)	Average width (m)	Average Depth (m)	Water volume of stream (m^3) (AL x AW x AWD x 7.48)
1.	Mithildil	Birishishiwa	47.05	29.25	1.20	12,352.88
2.	Evali	Pallam	75.95	39.0	0.90	19,940.52
3.	Zhau	Dzuel	127.25	101.50	1.15	111,102.36
4.	Vami	Dzuel	56.9	44.6	0.7	13,287.60

Key: AL = Average length AW = Average width AW D = Average water depth 7.48 = Standard
Source: Field Survey (2024)

Assessment of Lost Water Volume of Pond

Assessment of the lost volume of ponds (Table 6) showed that Zhau pond (62,796.98m^3) had the highest, followed by Evali (12,185.87m^3). In terms of percentage lost, Evali pond (37.93%) lost more water than Zhau (36.11%). The twist in percentage of lost water volume record in Evali pond may be connected to the rate of patronage of fishers to the Evali pond and possibly because of its utilization for small scale irrigation farming. This finding agrees with the Ministry of Environment (2020) report that excessive patronage of water body for fishing is one of the most significant drivers of water loss in streams and ponds.

Table 6: **Assessment of Lost Water Volume of Pond**

S/No.	Name of water body	Location	E_{vol} (m^3)	R_{vol} (m^3)	L_{vol} (E_{vol} - R_{vol}) m^3	Percentage (%) of lost water volume of pond
1.	Mithildil	Birishishiwa	17,499.92	12,352.88	5,147.04	29.41
2.	Evali	Pallam	32,126.39	19,940.52	12,185.87	37.93
3.	Zhau	Dzuel	173,899.34	111,102.36	62,796.98	36.11
4.	Vami	Dzuel	18,982.30	13,287.60	5,694.70	30.0

Key: E_{vol} = Expected volume R_{vol} = Realized volume L_{vol} = Lost volume

Source: Field Survey (2024)

Fish Species of the Study Area

The fish species found in the streams and ponds of the study area were identified in terms of species richness (Table 7). The checklist indicates that 13 fish species belonging 6 families were identified. The number of species in each family were as follows; Schilbedae (3), Mormyridae (3), Clariidae (2), Mockokidae (2), Cichlidae (2) and Alestidae (1). In addition, respondents reported that the family Clariidae tends to be most thriving species in the study area as they are found across almost all water bodies exceeding all other families in productivity.

The respondents' observation agrees with Bawa (2024) that Clariidae family popularly refer to as African catfish can thrive in even harsh environment thereby guaranteeing their productivity because of fecundity rate and tolerance to diverse environmental conditions.

Table 7: **Checklist of the Fish Species of the Study Area**

S/n	Family name	Scientific name	English name	Hausa name (local dialect)
1.	Clariidae	*Clarias lazera*	African catfish	Farin tarwada
2.	Clariidae	*Clarias gariepinus*	African mud catfish	Bakin tarwada
3.	Mochokidae	*Synodontis clarias*	Catfish	kurungu
4.	Mochokidae	*Synodontis nigrita*	Catfish	Kurungu
5.	Cichlidae	*Tilapia zilli*	Tilapia	parpasa
6.	Cichlidae	*Oreochromis niloticus*	Nile tilapia	parpasa
7.	Schilbedae	*Schilbe mystus*	Butterfish	Nalanga (farin utsiya)
8.	Schilbedae	*Schilbe intermedius*	Butterfish	Nalanga
9.	Schilbedae	*Schilbe uranoscopus*	Butterfish	Nalanga
10.	Mormyridae	*Mormyrus longirostris*	African lung fish	Milligi
11.	Mormyridae	*Mormyrus niloticus*	Trunk fish	miligi
12.	Mormyridae	*Protopterus annectans*	African lung fish	Mai mama
13.	Alestidae	*Alestes dentex*	characan	shemani

Source: Field Survey (2024)

Fish Productivity of Streams and Ponds

The result of assessment of fish productivity of streams and ponds as presented in Table 8 below based on pooled result using Smith Saliency value showed that the highest record of fish productivity was recorded for *Clarias gariepinus* (0.2972), followed by *Clarias lazera* (0.2395) and *Tilapia zilli* (0.1269). All other fish species productivity ranged from 0.0094 for *Synodontis nigrita* to 0.0691 for *Schilbe mystus*. The quantity of fish caught per community presented in descending order showed Kwajiti (3,962kg), Birishishiwa (3,618kg), Kwakwahu (3,388kg), Pallam (2,769kg) and Dzuel (2,395kg).

The result of this study agrees with Bawa (2024) and Alassane (2023) that the *Clarias* and *Tilapia* species thrive well in tropical streams especially if the water body is less disturbed because of their ability to adapt easily to harsh environment and the relative high reproductive rate.

Table 8: **Fish Productivity of Streams and Ponds of the study Area from 2022 – 2024 in Kilogrammes based on Locations and Fish Species**

Scientific name	Kwajiti	Pallam	Frequency of Dzuel	Respondents Birishishiwa	Kwakwahu	Total	Saliency value
Clarias lazera	900 (22.72)	765 (27.63)	417 (17.44)	965 (26.74)	816 (24.67)	3863 (23.95)	0.2395
Clarias gariepinus	813 (20.52)	995 (35.93)	918 (38.33)	1,065 (29.44)	1,004 (29.63)	4795 (29.72)	0.2972
Synodontis clarias	164 (4.14)	102 (3.68)	155 (6.47)	240 (6.63)	125 (3.69)	786 (4.87)	0.0487
Synodontis nigrita	36 (0.91)	25 (0.90)	54 (2.25)	18 (0.50)	25 (0.74)	158 (0.9794)	0.0094
Tilapia zilli	587 (14.82)	255 (9.21)	450 (18.79)	385 (10.64)	370 (10.92)	2,047 (12.69)	0.1269
Oreochromis niloticus	182 (4.59)	116 (4.19)	37 (1.54)	166 (4.59)	45 (1.33)	546 (3.38)	0.0338
Schilbe mystus	524 (13.23)	135 (4.88)	-	200 (5.75)	250 (7.38)	1,117 (6.92)	0.0691
Schilbe intermedius	-	55 (1.99)	105 (4.38)	71 (1.96)	-	231 (1.43)	0.0143
Schilbe uranoscopus	98 (2.47)	42 (1.52)	-	55 (1.52)	155 (4.57)	350 (2.17)	0.0217
Mormyrus longirostris	90 (2.47)	98 (3.59)	65 (2.71)	142 (3.95)	-	396 (2.45)	0.0245
Mormyrus niloticus	345 (8.71)	65 (2.35)	121 (5.05)	85 (2.35)	225 (6.64)	841 (5.21)	0.0521
Protopterus annectans	203 (5.12)	50 (1.81)	73 (3.05)	150 (4.15)	240 (6.64)	716 (4.44)	0.0444
Alestes dentex	20 (0.50)	66 (2.38)	-	67 (1.85)	133 (3.92)	546 (1.69)	0.0169
Total	**3,962**	**2,769**	**2,395**	**3,618**	**3,388**	**16,132**	

Source: Field Survey (2024)
***Figures in parenthesis are in percentages (%)**

Assessment of Yearly Productivity of the Streams and Ponds

The assessment of yearly fish productivity of the streams and ponds based on quantity of fish caught indicated that the fish harvested in 2024 (7,964kg) was more than 2022 (4,664kg) and more than double of the one harvested in 2023 (3,504kg) as presented in Table 9. Respondents reported that the poor harvest of fish experienced in 2023 was attributed to the inadequate rainfall recorded for that season. The relatively low amount of rainfall recorded in 2023 could not provide an environment suitable for fish reproduction and growth in the streams and ponds.

Table 9: **Fish Productivity of Streams and Ponds of the study Area for Three Years (2022 – 2024) in Kilogrammes**

Name of locations/Communities	**2022 (Kg)**	**Frequency of 2023 (Kg)**	**Respondents 2024 (Kg)**	**Total (Kg)**	**Saliency value**
Kwajiti	961 (20.60)	794 (22.66)	1,106 (13.89)	2,861 (17.73)	0.1773
Pallam	713 (15.29)	680 (19.41)	1,639 (20.58)	3,032 (18.79)	0.1879
Dzuel	817 (17.51)	495 (14.13)	1,435 (18.02)	2,474 (17.03)	0.1703
Birishishiwa	1,099 (23.56)	723 (20.63)	2,138 (26.85)	3,960 (24.55)	0.2455
Kwakwahu	1,074 (23.03)	812 (23.17)	1,646 (20.67)	3,532 (21.89)	0.2189
Total	**4,664 (28.91)**	**3,564**	**7,964**	**16,132**	

Source: Field Survey (2024)

***** Figures in parenthesis are in percentages

Assessment of Factors Affecting the Sustenance and Productivity of Tropical Streams and Ponds

Information on the ranking of factors affecting the sustenance and productivity of tropical streams and ponds in Madagali local government area assessed using 5 communities is presented below in Table 10. Result of multiple responses were obtained from the respondents. Analysis of multiple responses using descriptive statistics (percentage) showed that the percentage of respondents who reported; no effect ranged from 0.83% for excess silting resulting from poor farming practices and agricultural expansion to insecurity causing inability to access fish from Gwambale, Gamboru/Ngala and Alau Dam in Borno State with 9.17%.

Respondents that reported worse effect ranged from 21.67% for lack of orientation of the fishers/fish consumers in stream and pond management to farming along and around the stream and pond banks in search of fertile land (alluvium) that recorded 62.50%.

Similarly, the percentage of respondents for worst effect was 2.50% for excavation of some ponds for clay soil supply to potters to poor fishing practices characterized by partitioning of streams into paddocks and total draining of water mostly using the power pumping machine with 29.17%. In line, investigation revealed that of the 19 factors threatening the sustenance and productivity of the streams in the study area (Table 10), the four (4) highly ranked factors as perceived in order of endangerment based on the high percentages recorded in the categories of worst and worse effects for both are poor fishing practices characterized by partitioning of streams into paddocks and total draining of water mostly using the water power pumping machine (29.17% and 27.50%), agricultural expansion (24.17% and 48.33%), use of gamalin 20 and other chemicals by youths for pond fishing (23.33% and 50.83%) and increased demand for fish protein due to human population growth (20.83% and 45.83%) are the leading threatening factors on the water bodies in the study area.

The top ranking of the above factors especially poor fishing practices characterized by partitioning of streams into paddocks and total draining of water mostly using the water power pumping machine, agricultural expansion and the use of chemicals are serious danger to water resources productivity. These factors if not curtail will mean doom not only to fish productivity but to human, wildlife and the aquatic biodiversity therein. Albou *et al*. (2024) earlier observed that agricultural practices and use of chemicals have serious effect on flora and fauna of the aquatic ecosystem.

Table 10**: Factors Affecting the Sustenance and productivity of Tropical Streams and Ponds (% of Respondents)**

S/N	Factors	No effect	Frequency of Fair effect	Respondents Bad effect	Worse effect	Worst effect
1.	Poor fishing practices characterized by partitioning of streams into paddocks and total draining of water using power pumping machine	2 (1.67)	7 (5.83)	43 (35.83)	33 (27.50)	35 (29.17)
2.	Farming along and around the stream and pond banks in search of fertile land (alluvium)	2 (1.67)	11 (9.17)	23 (19.17)	75 (62.50)	9 (7.50)
3.	Lack of modern fishing equipment	5 (4.17)	15 (12.50)	48 (40.0)	46 (38.33)	6 (5.0)
4.	Natural forces such as erosion	-	6 (5.0)	28 (23.33)	74 (61.67)	12 (10.0)
5.	Excessive silting resulting from poor farming practices	1 (0.83)	13 (10.83)	60 (50.0)	31 (25.83)	15 (12.50)
6.	Agricultural expansion	1 (0.83)	6(5.0)	26 (21.67)	58 (48.33)	29 (24.17)
7.	Increased demand for fish protein due to human population growth	-	4 (3.33)	36 (30.0)	55 (45.83)	25 (20.83)
8.	Increased acceptability of irrigation practice by the local residents	3 (2.50)	20 (16.67)	40 (33.33)	39 (32.50)	18 (15.0)
9.	Unprecedented demand for large quantities of water by Roads construction workers	5 (4.17)	16 (13.33)	43 (35.83)	41 (34.17)	15 (12.50)
10.	Overdependence on fish resources as means of income for arable farmers/low income	8 (6.67)	9 (7.50)	53 (44.17)	42 (35.0)	8 (6.67)
11.	Insecurity causing inability to access fish from Gwambali, Gamboru/Ngala and Alau Dam in Borno state	11 (9.17)	32 (26.67)	37 (30.83)	29 (24.17)	11 (9.17)
12.	Over-utilization of the water bodies due to claim of ownership by the local residents/landowners	8 (6.67)	16 (13.33)	30 (25.0)	50 (41.67)	16 (13.33)
13.	Misuse of the water bodies especially ponds by the pastoralists	7 (5.83)	15 (12.50)	25 (20.83)	63 (52,50)	10 (8.33)
14.	Lack of orientation of the fishers/fish consumers in stream and pond management	6 (5.0)	12 (10.0)	61 (50.83)	26 (21.67)	15 (12,50)

15.	Increased demand for fish by neighboring communities	3 (2.50)	38 (31.67)	35 (29.17)	27 (22.50)	17 (14.17)
16.	Inability of the local dwellers to afford mutton, beef, pork etc. because of high cost	7 (5.83)	5 (4.17)	59 (49.17)	33 (27.50)	16 (13.33)
17.	Use of Gamalin 20 and other chemicals by youths for pond fishing	-	8 (6.67)	23 (19.17)	61 (50.83)	28 (23.33)
18.	Pollution of the water bodies by agricultural chemicals	4 (3.33)	5 (4.17)	36 (30.0)	57 (47.50)	18 (15.0)
19.	Excavation of some ponds for clay soil supply to potters	4 (3.33)	12 (10.0)	52 (42.50)	50 (41.67)	3 (2.50)

Source: Field Survey (2024)
***Figures in parenthesis represent percentages

Management Strategies Currently in use for the Sustenance and Productivity of Streams and Ponds in the Study Area

Table 11 below shows the management strategies currently in use for the sustenance and productivity of streams and ponds in the study area. Respondents reported that the 4 management strategies in place have failed to address the problems of factors threatening the fish productivity of the water bodies. According to the respondents, all the strategies lack enforcement to help curtail the issue because the machineries use for implementation of traditional institution and community participation by-laws are weak and lack effective supervision resulting from bad governance.

Table 11**: Management Strategies Currently in use for the Sustenance and Productivity of Streams and Ponds in the Study Area (% of Respondents)**

Management Strategies	**Birishishiwa**	**Dzuel**	**Frequency of Kwajiti**	**Respondents Kwakwahu**	**Pallam**	**Total**	**Saliency Value**
Use of traditional institution	11 (42.31)	6 (31.58)	8 (33.33)	5 (25.0)	7(22.58)	37 (30.83)	0.3083
Community participation in stream and pond management	13 (50.0)	-	12 (50.0)	9 (45.0)	4 (12.90)	38 (31.67)	0.3167
Patrol by local government officials	5 (19,23)	3 (15.79)	6 (25.0)	-	3 (9.68)	17 (14.17)	0.1417
Ownership management	6 (23.08)	9 (47.37)	14 (58.33)	11 (55.0)	15(48.39)	55 (45.83)	0.4583

Source: Field Survey (2024)
***Figures in parenthesis represent percentages

Suggested Management Strategies that could be Adequate for the Sustenance and Increased Fish Productivity of Streams and Ponds

The study suggested 11 management strategies that was analyzed using Likert scale as presented in Table 12. The result showed that 55 respondents representing 45.83% of the sampled population strongly agreed that adoption of restoration process of water bodies through controlled fishing, followed by provision of alternative fish source to divert people's attention from stream and overexploitation (40.0%) and provision of buffer zones between farming sites and water bodies to aid bank consolidation (39.17%) could be the leading strategies that can address the factors threatening the sustenance of tropical streams and ponds if effectively put to use.

The polled result of strongly agreed and agreed are indications that the respondents have considered the listed strategies adequate for the sustenance of the streams and ponds.

Table 12**: Suggested Management Strategies that could be Adequate for the Sustenance and Increased Productivity of Streams and Ponds (% of Respondents)**

S/No.	**Management Strategies**	**Strongly agreed**	**Frequency of Agreed**	**Respondents Disagreed**	**Strongly disagreed**	**Undecided**
1.	Reduced farming practice along and around the streams and ponds	46 (38.33)	56 (46.67)	12 (10.6)	-	6 (5.0)
2.	Adoption of restoration process of the water bodies through controlled fishing	55 (45.83)	45 (37.50)	11 (9.17)	2 (1.67)	7 (5.83)
3.	Mass enlightenment of the local fishers and users of the water bodies through environmental education	32 (26.67)	47 (39.17)	19 (15.83)	8 (6.67)	14 (11.67)
4.	Provision of alternative and affordable fish source to divert people's attention from stream and pond overexploitation	48 (40.0)	36 (30.0)	17 (14.17)	4 (3.33)	15 (12,50)
5.	Establishing community laws for conservation of the water bodies	31 (25.83)	40 (33.33)	23 (19.17)	12 (10.0)	14 (11.67)
6.	Total stoppage of use of stream and pond water for roads construction	39 (32.50)	43 (35.83)	13 (10.83)	10 (8.33)	15 (12.50)
7.	Use of modern equipment for fishing to protect the fingerlings	43 (35.83)	44 (36.67)	9 (7.50)	5 (4.17)	19 (15.83)
8.	Provision of buffer zones between farming sites and water bodies to aid bank consolidation	47 (39.17)	49 (40.83)	9 (7.50)	3 (2.50)	12 (10.0)
9.	Fighting insecurity in the area and beyond to help access the popular fish sources (Gamboru/Ngala, Gwambale and Alau Dam) among others	14 (11.67)	41 (34.17)	43 (35.83)	9 (7.50)	13 (10.83)
10.	Encourage livestock production to divert peoples' attention of catching of fingerlings to increase productivity	35 (29.17)	38 (31.67)	23 (19.17)	4 (3.33)	20 (16.67)

Source: Field Survey (2024)
***Figures in parenthesis represent percentage

CONCLUSION

The study identified and assessed the water volumes and fish productivity of 8 streams and 4 ponds in Madagali local government area of Adamawa state, Nigeria. The investigation recorded 13 fish species which are good representative indicators of freshwater fish species found in tropical streams and ponds. These species however are not very diverse possibly because of natural and human induced environmental factors that tend to militate against the survival of other fish species of freshwater.

The leading factor affecting the sustenance and fish productivity of the water bodies is poor fishing practices characterized by partitioning of streams and total draining of water using power pumping machine based on the respondents view on worst and worse effect scale of assessment. What is required is complete adoption of the suggested strategies for the sustenance of the water bodies. Thus the present investigation has provided the basic strategies to use in order to prevent the loss of current existing fish species that are still thriving well in the water bodies especially *Clarias gariepinus, Clarias lazera* and *Tilapia zill*i for sustainable production and supply of fish protein.

Recommendations

The present study recommends that;

i. The suggested strategies be strictly adhere to in order to prevent further deterioration of the water bodies
ii. Fishing in the streams and natural ponds should be made periodic in order to control fishers excesses and abuse of protective strategies

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Fish Species with High productivity in Streams and Ponds of Madagali Local Government Area, Adamawa State, Nigeria based on quantity caught from 2022 to 2024.

Plate 1: *Tilapia zilli*

Plate 2: *Clarias gariepinus*

Plate 3: *Schilbe mystus*

Plate 4: *Clarias lazara*

Plate 5: *Mormyrus niloticus*

Plate 6: *Synodontis clarias*