Indian J. Fish., 73 (3): 45-55, 2026 doi:10.21077/ijf.2026.73.3.178977-05

Available online at: epubs.icar.org.in/index.php/IJF

Destructive fishing practices and governance challenges in the Jemma River Sub-basin, Ethiopia: Fishers' perspectives on sustainable fisheries management

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Abstract

Destructive fishing threatens inland fisheries and aquatic biodiversity in Ethiopia, yet quantitative evidence from riverine ecosystems remains limited. This study assessed the types, extent, perceived drivers, governance challenges, and fishers' perceptions of destructive fishing in the Jemma River Sub-basin, Upper Blue Nile Basin, Ethiopia. Data were collected through semi-structured questionnaires, key informant interviews (KIIs), focus group discussions (FGDs), and field observations. Descriptive statistics, chi-square tests, and Kruskal-Wallis tests were applied. Fishers were predominantly male (95.84%) with low educational attainment. Most (64.67%) of fishers engaged mainly in subsistence fishing for household food security. Traditional plant poisoning, river diversion and drying, and chemical poisoning were perceived as the three most destructive fishing practices. Fishers identified high fishing efficiency, low cost, local availability, weak governance, limited awareness, absence of fishing licenses, local tolerance, migrant fishers, and overfishing as major perceived socioeconomic and governance factors associated with the continued use of destructive fishing practices. Fishers' perceptions differed significantly among rivers for six aspects *viz.,* Persistence and escalation of destructive fishing; Use of destructive practices instead of other gears; Government efforts; Community awareness and Kebele-level management (Kruskal–Wallis test, $p<0.05$). However, perceptions of the effectiveness of previous control efforts did not differ significantly ($p=0.527$). Law enforcement, awareness raising, promotion of legal fishing gears, and expansion of community based co-management is essential for conserving fish biodiversity and ensuring the sustainability of riverine fisheries in the Jemma River system.

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Keywords:
Aquatic biodiversity, Kebele-level management, River diversion, Riverine fisheries, Upper Blue Nile Basin

Received : 13.05.2026
Accepted : 23.09.2026

Introduction

Fishing is an important livelihood that provides food security, income, and employment for millions of people worldwide (Funge-Smith and Bennett, 2019). However, increasing demand for fish, population growth, and economic pressures have intensified fishing activities, leading to widespread use of illegal and destructive fishing methods to maximise short-term catches and profits (Ranjan *et al*., 2023; Tuasuun *et al*., 2025). Destructive fishing refers to the use of explosives, poisons, small-mesh sized nets and other illegal or non-selective fishing gears and practices that damage aquatic habitats, disrupt ecosystem functioning, and reduce fish populations through indiscriminate harvesting of target, non-target, and juvenile fish (Tahiluddin and Sarri, 2022). These practices can reduce fish recruitment, biodiversity, fisher safety, consumer health and fisheries productivity (Tahiluddin and Sarri, 2022; Ranjan *et al*., 2023; Tuasuun *et al*., 2025). Because of these ecological and socioeconomic impacts, the Food and Agriculture Organization (FAO) recognises destructive fishing as a major threat to sustainable fisheries management (FAO, 2010).

In Ethiopia, inland fisheries contribute to food security, improved nutrition, and income generation for riparian communities (Tesfaye and Wolff, 2014; Wendimu *et al*., 2024). The sector supports approximately 15,000 full-time fishers and an additional 20,000 people engaged in fisheries related activities (FAO, 2024). Ethiopia's annual sustainable inland fish production potential is estimated at approximately 94,500 t (Tesfaye and Wolff, 2014). Despite their socioeconomic importance, illegal and destructive fishing practices remain widespread and continue to threaten fish stocks, aquatic biodiversity, and the sustainability of inland fisheries (Deng, 2020; Eyayu and Getahun, 2022; Zeleke and Gubale, 2026).

Understanding fishers' perceptions of destructive fishing practices is critical for developing effective and sustainable fisheries management strategies (Katikiro and Mahenge, 2016). However, destructive fishing practices remain poorly understood and inadequately addressed in tropical inland fisheries (Betts *et al*., 2020). Although several studies have reported destructive fishing in Ethiopian inland waters (Mequanent *et al*., 2021; Eyayu and Getahun, 2022; Wendimu *et al*., 2024), quantitative evidence on their prevalence, perceived drivers, and governance challenges in riverine fisheries remains limited.

The Jemma River, a major tributary of the Upper Blue Nile Basin (Worku *et al*., 2021), supports diverse fish communities and local livelihoods, but destructive fishing and weak fisheries governance threaten its sustainability (Asmare *et al*., 2016). Information on the extent of destructive fishing and the socioeconomic factors driving these practices remains scarce. Therefore, this study investigated destructive fishing practices and governance challenges in the Jemma River and its tributaries from the perspectives of fishers' perspectives. Specifically, the study aimed to identify the major destructive fishing practices used in the river system and their extent; examine the socioeconomic and governance factors contributing to their persistence; and evaluate fishers' awareness of fisheries regulations and their willingness to participate in mitigation and co-management initiatives.

Materials and methods

Study area

The study was conducted in the Jemma River Sub-basin, located in the Upper Blue Nile (Abbay River) Basin, central Ethiopia (Fig. 1). The Jemma Sub-basin covers approximately 15,782 km^2, with elevations ranging from 1,040 to 3,814 m above sea level, with a mean annual rainfall of 700 to 1,400 mm and mean annual temperatures of 9 to 24°C (Worku *et al*., 2021; Hilemicael *et al*., 2022). It accounts ~8% of the area and contributes ~14% of the total annual flow of the Upper Blue Nile Basin (Worku *et al*., 2021). The Jemma River is a major westward flowing tributary of the Upper Blue Nile, with the Beresa, Grit, Moferwuha and Chacha rivers as its principal tributaries (Worku *et al*., 2021). It supports diverse fish populations and provides subsistence food and income opportunities for local communities (Asmare *et al*., 2016).

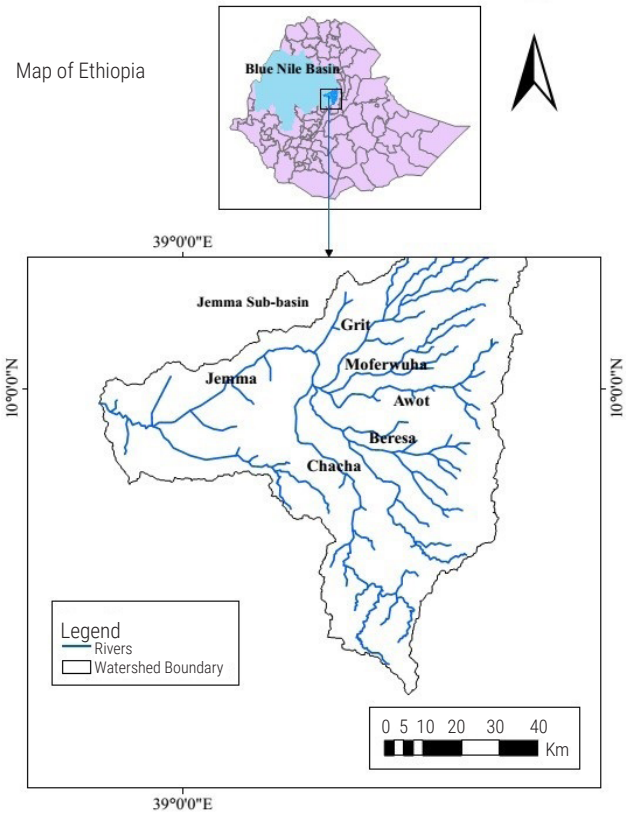

Fig. 1. Map showing Jemma and tributary river network

Sampling procedure and data collection methods

Ethical approval for this study was obtained from the Institutional Research Ethics Review Committee of Debre Berhan University (Protocol Code: DBU/094/2026). The study involved human participants through fisher interviews, focus group discussions (FGDs) and key informant interviews (KIIs) and was conducted in accordance with relevant ethical guidelines and regulations. Before participation, all participants were informed about the purpose and procedures of the study, and written informed consent was obtained. Participation was voluntary, and participants were informed of their right to decline participation or withdraw at any time without penalty. For participants under 18 years of age, written informed consent was obtained from their parents or legal guardians. All information was kept confidential and used solely for research purposes.

Data were collected from March 2024 to February 2025 in the Jemma River and three tributaries Beresa, Grit and Moferwuha using semi-structured questionnaires, key informant interviews (KIIs), focus group discussions (FGDs), and direct field observations. As no recent official records of fishing households were available, a non-probability sampling approach was used. Eleven fishing villages were purposively selected based on their representation of the major fishing communities along the Jemma River and its tributaries. Within each village, fishers were purposively selected based on their active involvement, fishing experience, and regular participation in fishing activities. The required sample size was estimated using Cochran's (1977) formula for an unknown population at a 95% confidence level (Z=1.96) and a 5% margin of error (e=0.05):

$$\text{Sample size (n)} = \frac{z^2}{4e^2} \; ; \quad n = \frac{1.96^2}{4(0.05)^2} = 384.16 \approx 385$$

To ensure balanced representation and facilitate comparisons among villages, 35 fishers were interviewed from each of the 11 fishing villages, yielding 385 respondents in total. Because the final respondents were selected purposively rather than through probability sampling, the confidence level and margin of error in Cochran formula were used only as a guide for determining the target sample size and should not be interpreted as measures of statistical representativeness.

A total of 23 key informants, comprising 8 fisheries experts (two experts from each of four districts), 11 community leaders (one from each of the 11 villages), and 4 fish traders, were purposively selected based on their knowledge of local fisheries. In addition, five FGDs were conducted (two in the Jemma River and one in each tributary), each involving 4-8 fishers, a community leader, and a local agriculture/fisheries expert. Direct field observations were conducted to observe fishing activities, gears and fish catches.

Data analysis

Data were coded in Microsoft Excel and analysed using SPSS version 20.0. Descriptive statistics were used to summarise fishers' socio-demographic characteristics and fishing practices. Chi-square and Kruskal–Wallis tests were performed to examine differences among rivers. Annual fishing days were estimated from fishers' reported fishing frequency. Following Zeleke and Gubale (2026), annual fish production and household fish consumption were estimated by multiplying the reported daily fish harvest and daily household fish consumption, respectively, by annual fishing days. Annual fishing income was estimated by multiplying reported daily income from fish sales by annual fishing days. It was calculated only for fishers who reported income from fish sales. Thus, the annual fishing income analysis was based on 155 respondents, whereas the other fishing related variables were based on the full survey sample. Fishers who did not report fish sale income were treated as missing for this analysis rather than as zero income. The normality of these variables was assessed using the Shapiro–Wilk test. Because the variables were not normally distributed ($p<0.05$), results are presented as median and interquartile range (IQR), and differences among rivers were evaluated using the Kruskal–Wallis test. For variables showing significant overall differences among rivers, pairwise Mann–Whitney U tests were conducted with Bonferroni adjustment for multiple comparisons. Statistical significance was accepted at $p<0.05$.

Fishers' perceptions of destructive fishing were assessed using seven statements measured on a five-point Likert scale, coded from 1=Strongly agree to 5=Strongly disagree. Each statement was treated as a separate ordinal item because the statements addressed different aspects of fishers' perceptions. Response distributions, median scores, and interquartile ranges (IQR) were calculated for each statement by river. Differences among the four rivers were assessed separately for each statement using the independent-samples Kruskal–Wallis test. When the overall test was significant ($p<0.05$), pairwise comparisons were examined using the adjusted significance values provided by the SPSS nonparametric procedure, with adjusted p-values <0.05 considered statistically significant.

Qualitative information from the 23 KIIs and five FGDs was used to complement the quantitative findings. The discussions were conducted in Amharic, and FGDs were audio-recorded. The recordings were reviewed and notes were taken to identify common and recurring themes. These findings were compared with the questionnaire results, and selected participant views were used to explain and support the quantitative findings.

Results and discussion

Socio-demographic characteristics of the fishers

Among the 385 fishers surveyed, the majority was male (95.84%), while females accounted for 4.16% (Table 1). The dominance of male fishers reflects the traditional gender division of labour in Ethiopian fisheries, where men primarily engage in fishing while women are more involved in fish processing and marketing (Asmare *et al*., 2017; FAO, 2024; Zeleke and Gubale, 2026). Most fishers were 19 to 35 years old (34.29%), followed by those aged 36 to 50 years (32.73%). This high proportion of young and active-age fishers reflects the physically demanding nature of riverine fishing, which typically requires considerable time and energy (Zeleke and Gubale, 2026).

Educational attainment was relatively low, with 37.40% completing primary education and 25.19% having no formal education. Similar

Table 1. Socio-demographic background of fisher respondents

Variable	Category	Percentage (%) of respondents in rivers				Total (%)	p
		Jemma (N = 175)	Beresa (N = 70)	Moferwuha (N = 70)	Grit (N=70)		
Gender	Men	90.86	100.00	100.00	100.00	95.84	< 0.001
	Women	9.14	0.00	0.00	0.00	4.16	
Age (Year)	15-18	12.57	15.71	18.57	14.29	14.54	0.301
	19-35	40.00	31.43	24.29	32.8	34.29	
	36-50	30.29	34.29	31.43	38.57	32.73	
	51-72	17.14	18.57	25.71	14.29	18.44	
Marital status	Married	54.86	65.71	61.43	68.57	60.52	0.275
	Unmarried	42.29	30.00	35.71	31.43	36.88	
	Divorced	2.86	4.29	2.86	0.00	2.60	
Academic level	Illiterate	20.00	31.43	37.14	20.00	25.1	0.447
	Adult education	9.14	10.00	7.14	17.14	10.39	
	Primary education	42.29	32.86	27.14	40.00	37.40	
	Secondary school	20.57	21.43	25.71	20.00	21.56	
	Certificate	1.14	0.00	0.00	1.43	0.78	
	Diploma	5.71	2.86	2.86	1.43	3.90	
	Degree	1.14	1.43	0.00	0.00	0.78	
Family size (No.)	<3	4.57	2.86	0.00	1.43	2.86	0.902
	3-5	67.43	71.43	68.57	67.14	68.31	
	6-8	28.00	25.71	31.43	31.43	28.83	
Fishing experience (No. of years)	1-5	24.57	27.14	22.86	21.43	24.16	0.001*
	6-11	21.14	15.71	12.86	11.43	16.88	
	12- 17	22.29	5.71	7.14	10.00	14.29	
	18- 23	10.29	14.29	18.57	22.86	14.80	
	> 23	21.71	37.14	38.57	34.29	29.87	

lower educational attainment patterns have been reported among small-scale fishers in Ethiopia (Teame *et al*., 2016; Getahun *et al*., 2020; Zeleke and Gubale, 2026). Most fishers (68.31%) had household sizes of 3-5 members, and 29.87% had more than 23 years of fishing experience. The high family size and experienced fishers suggesting a strong dependence on fisheries for livelihoods (Alemu and Azadi, 2018; Amadu *et al*., 2021). Sociodemographic characteristics did not differ significantly among study rivers (chi-square test, $p>0.05$), except for fishing experience ($p<0.05$).

Fish utilisation and fish species preferences

Most fishers (64.67%) harvested fish primarily for domestic consumption, whereas 31.95% used their catch for both consumption and sale purposes. Only 3.38% fishers captured fish exclusively for commercial purposes. The predominance of subsistence fishing highlights the importance of small-scale fisheries for household nutrition and livelihoods, consistent with the findings of Asmare *et al*. (2016); Wendimu *et al*. (2024), and Zeleke and Gubale (2026). Fish utilisation differed significantly among rivers ($\chi^2=18.36$, df=6, $p=0.005$); possible explanations include differences in market access, remoteness, and livelihood opportunities (Poissant *et al*., 2023).

Clarias gariepinus was the most preferred species in tributaries (24.29–31.43%), and *Heterobranchus longifilis* found most preferred in places near to Jemma River (33.71%) (Table 2). *Oreochromis niloticus* was less preferred by fishers, particularly near to Jemma (2.86%) and Beresa (11.43%) rivers. Similarly, Asmare *et al*. (2016) reported that *O. niloticus* was less preferred by fishers in the Jemma and Wonchit rivers, whereas *H. longifilis*, *C. gariepinus* and *Labeobarbus intermedius* were among the most preferred species. This finding contrasts with Tesfaye and Wolff (2014), who reported that *O. niloticus* is the most preferred species for consumption in Ethiopia. These results indicates that fisher's species preferences are influenced by catch abundance, fish size, taste, market value, and cultural factors (Tecklie *et al.,* 2024).

Annual fisheries production, household fish consumption and income

Annual fishing days, fish production, household fish consumption, and annual fishing income differed significantly among the rivers, whereas daily income from fish sales did not differ significantly among rivers (Kruskal–Wallis, H=1.882, p=0.597; Table 3). Fishers from the Jemma River reported the highest fishing effort, production, consumption, and income relative to those from the tributaries. These differences may be associated with variation in fishing intensity, fish availability, habitat suitability, and market access (Funge-Smith and Bennett, 2019; Poissant *et al*., 2023).

Patterns of fishing gear use and fishers' perceived destructiveness

Respondents were asked, "Which fishing gears or methods have you personally used?" Multiple responses were allowed, so respondents could report more than one gear or method. For interpretation, the reported gears and methods were distinguished as conventional

Table 2. Percentage of fishers reporting most preferred fish species in the studied rivers

Scientific name	Local name	Jemma	Beresa	Moferwuha	Grit
Heterobranchus longifilis	Gilgel	33.71	18.57	2.86	11.43
Clarias gariepinus	Zemet	20.00	24.29	27.14	31.43
Bagrus bajad and *Bagrus docmak*	Ferekus	17.71	17.14	0.00	8.57
Oreochromis niloticus	Fada, Qurqushit	2.86	11.43	21.43	15.71
Labeobarbus intermedius	Bilicha, Shule	3.43	2.86	5.71	5.71
Labeobarbus nedgia	Futa, Mutmut, Buat	5.71	8.57	8.57	8.57
Labeobarbus beso	Duldumat	4.00	4.29	11.43	5.71
Labeo forskalii	Teymat	12.57	12.86	22.86	12.86

Table 3. Comparison of annual fishing effort, fisheries production, household fish consumption and fishing income of fishers in the rivers studied

Variable	Jemma	Beresa	Moferwuha	Grit	H	p
Annual fishing days (days per year)	104^{a} (52)	52^{b} (52)	52^{ab} (52)	52^{b} (52)	18.198	<0.001
Annual fish production (kg per year)	832^{a} (1,044)	780^{b} (780)	468^{ab} (546)	390^{b} (468)	17.444	0.001
Annual household fish consumption (kg per year)	208^{a} (208)	104^{b} (156)	104^{b} (117.25)	91^{b} (143.38)	31.122	<0.001
Daily income from fish sales (ETB per day)	1,000 (700)	1,200 (700)	1,000 (450)	1,000 (625)	1.882	0.597
Annual fishing income (ETB per year)	$93{,}600^{a}$ (145,600)	$52{,}000^{ab}$ (104,000)	$62{,}400^{ab}$ (72,800)	$57{,}200^{b}$ (67,600)	12.368	0.006

Values are presented as median (IQR), where IQR is the interquartile range (75th percentile − 25th percentile). H = Kruskal–Wallis test statistic. Different superscript letters indicate significant differences between rivers based on pairwise Mann–Whitney U tests with Bonferroni adjustment (α = 0.05). Values sharing at least one letter are not significantly different. Annual fish production, household fish consumption, and annual fishing income were calculated from reported daily quantities and estimated annual fishing days. Annual fishing income was reported by 155 of the 385 surveyed fishers and was therefore analysed separately using these respondents

fishing gears, illegal fishing methods, and destructive fishing practices. Conventional gears, such as hand lines, traditional cast nets, basket traps, and gillnet, were not considered inherently destructive when appropriately used. Poisoning, blasting or bombing, and river diversion and drying were treated as illegal and destructive fishing practices because of their potential to cause excessive fish mortality and habitat degradation. Gears or methods such as mosquito nets, monofilament gillnets, and fencing were considered potentially destructive where their use could result in excessive capture of juvenile fish, non-selective mortality, or habitat disturbance.

Among the eleven fishing gears and methods reported by respondents, mosquito nets (97.92%), traditional cast nets (93.77%), plant poison (90.13%), basket traps (90.13%), and river diversion and drying (86.75%) were the most frequently reported as personally used (Table 4).The reported use of hand line hook, traditional plant poison, chemical poison, monofilament gillnets, modern gillnets, and river diversion and drying differed significantly among rivers (χ^2, $p<0.05$), whereas the remaining gears showed no significant differences ($p>0.05$). These reported fishing gears and methods are consistent with previous reports from Ethiopian inland fisheries (Tesfaye and Wolff, 2014; Mequanent *et al*., 2021; Eyayu and Getahun, 2022; Wendimu *et al*., 2024).

To assess fishers' perceptions of the destructiveness of fishing gears and methods, each respondent was then asked to identify one fishing gear or method that they considered the most destructive. Traditional plant poisoning was ranked as the most destructive practice by 42.86% of fishers, followed by river diversion and drying (25.19%) and chemical poisoning (22.60%) (Table 5). The overall distribution of fishers' selected destructive fishing practices differed significantly among the rivers (χ^2=54.69, df=18, Monte-Carlo $p<0.001$). Plant poisoning was most frequently selected in Jemma

Table 4. Fishing gears and methods personally used by fishers in the rivers, with chi-square results

Fishing gears/ methods	Respondent percentage (%)				Overall%	p
	Jemma	Beresa	Moferwuh	Grit		
Hand line hook	83.43	85.71	81.43	98.57	86.23	0.009*
Traditional cast nets	96.57	90.00	94.29	90.00	93.77	0.123
Blasting or bombing	34.86	50.00	41.43	47.14	41.04	0.104
Plant poison	88.00	75.71	100.00	100.00	90.13	<0.001*
Chemical poison	57.14	84.29	81.43	82.86	71.17	<0.001*
Mosquito nets	98.23	95.71	98.57	98.57	97.92	0.556
Monofilament gillnets	47.43	24.29	22.86	28.57	35.32	<0.001*
Basket traps	89.71	84.23	94.23	92.86	90.13	0.198
Modern gillnet	44.00	7.14	10.00	18.57	26.49	<0.001*
River diversion and drying	81.14	87.14	94.29	92.86	86.75	0.015*
Fencing	9.14	11.43	8.57	5.7	8.83	0.692

Multiple responses were permitted. Percentages represent respondents who reported personally using each fishing gear or method and therefore may sum to more than 100%. *Indicates significant differences among rivers based on the Chi-square test (χ^2), $p < 0.05$

Table 5. Fishers' perceptions of the most destructive fishing gears and methods in the rivers studied

Fishing gears/methods	No. of fishers				Total fishers (%)	Rank
	Jemma	Beresa	Moferwuha	Grit		
Plant poison	89	27	26	23	165 (42.86)	1
River diversion and drying	52	18	16	11	97 (25.19)	2
Chemical poison	19	20	20	28	87 (22.60)	3
Mosquito nets	5	0	3	4	12 (3.12)	4
Blasting or bombing	2	1	3	4	10 (2.60)	5
Basket traps	2	4	2	0	8 (2.08)	6
Monofilament gillnets	6	0	0	0	6 (1.56)	7

Overall river × Destructive practice test: $\chi^2(18) = 54.69$, Monte-Carlo $p < 0.001$

River, whereas chemical poisoning was more frequently selected in Grit river. These fishing practices have been reported to cause fish mortality, habitat degradation, reduced recruitment, and biodiversity loss (Getahun *et al*., 2020; Aziz *et al*., 2021).

Poison fishing

Although poison fishing is prohibited in Ethiopia (Wendimu *et al*., 2024), the practice remains widespread in the study area, involving both traditional plant extracts and chemical pesticides. Fishers reported that, applying crushed plant toxicant parts or extracts in the water, causing fish to become immobilised and/or eventually float to the water surface, thereby facilitating their collection by hand or with locally available nets. This practice is locally known as MASKER/ASKIRET. A total of nine plant species were identified as fish poisons (Table 6). *Millettia ferruginea* (Birbira tree) was the most frequently reported species (312 respondents), followed by *Euphorbia abyssinica* (*Candelabra spurge)* and *Verbascum sinaiticum (Sinaitic mullein). The predominant use of M. ferruginea* seeds is consistent with previous studies conducted in Ethiopia (Eyayu and Getahun, 2022; Wendimu *et al*., 2024). Similarly, Asmare *et al.* (2016) documented *M. ferruginea* and *Balanites aegyptiaca* (Desert date) as commonly used fish-poisoning plants in the Jemma and Wonchit rivers. Field observations confirmed mortality of juvenile and small sized fish following plant poison fishing events (Fig. 2). These observations indicate the non-selective nature of poison fishing and its potential to affect fish of different size classes. The potential consequences for recruitment, fish community structure, and long-term population sustainability are supported by previous studies rather than directly demonstrated by the present cross sectional survey. Similar impacts have been reported in Ethiopian river systems, where they are associated with broad spectrum fish

Table 6. Plant species used for poison fishing, their parts, preparation methods, and respondent frequency

Plant species	Common name	Local name	Parts used	Report frequency
Millettia ferruginea	Birbira tree	Birbira	Seeds	312
Balanites aegyptiaca	Desert date	Bedeno	Bark	136
Euphorbia abyssinica	Candelabra spurge	Qulqual	Latex	264
Verbascum sinaiticum	Sinaitic mullein	Qetetina	Matured leaves	241
Grewia ferruginea	-	Lenquate	Leaves	89
Euphorbia tirucalli	Pencil tree	Qinchib	Latex	224
Calpurnia aurea	East African laburnum	Digita	Seeds	64
Datura stramonium	Thorn apple	Asefaris\Astenagir	Fruit and seeds	41
Croton macrostachyus	Broad leaved croton	Bisana	Seeds	81

Fig. 2. Juvenile and small sized fish left on the riverbank after fishers collected larger fish during a plant poison fishing event in the Jemma River system

mortality and reduced recruitment (Asmare *et al*., 2016; Desalegn and Shitaw, 2021; Mequanent *et al*., 2021).

In addition to plant-based ichthyotoxins, chemical poison fishing, locally known as Memerez is also practiced in the study area. Fishers reported using agricultural pesticides including Malathion (78 respondents), DDT (164), and Helerat/Palaze (λ-cyhalothrin 5% EC products (274). These chemicals were applied directly to isolated pools or immersing pesticide treated materials in the water to facilitate fish capture. Due to their non-selective toxic effects, such practices pose risks to fish communities and other aquatic organisms. Similar use of agricultural pesticides for fishing has been reported in other parts of Ethiopia (Eyayu and Getahun, 2022) and in other countries (Betts *et al*., 2020).

River diversion and drying

River diversion and drying (locally known as Adreq) was another widely reported destructive fishing method, particularly during the dry season. Fishers temporarily diverted or blocked upstream flow or excavated drainage channels to lower water levels in pools, making fish easier to capture (Fig. 3). Field observations showed that this practice also stranded fish in isolated pools, increasing their exposure to desiccation or predation by birds. River diversion may also degrade aquatic habitats and disrupt fish recruitment, consistent with previous reports from Ethiopian inland fisheries (Mequanent *et al*., 2021).

Blasting or bombing

Blast fishing (dynamite or bomb fishing) was as reported as an occasional but highly destructive practice. Explosions kill target and non-target organisms indiscriminately and cause severe damage to aquatic habitats (Hampton-Smith *et al*., 2021). During FGDs and KIIs, participants suggested that the increased availability of explosive materials might contribute to the occurrence of blast fishing in certain areas, although this perception was not independently verified. Respondents also reported the mortality of non-target wildlife, including Nile crocodiles and monitor lizards.

Mosquito nets

Mosquito nets (Agober) were widely used for fishing. Because of their extremely fine mesh (<3 mm), mosquito nets can capture fish of different size classes, including juveniles, and may therefore increase the risk of juvenile mortality and recruitment impacts (Short *et al*., 2018). Their widespread use has also been documented in Ethiopia (Eyayu and Getahun, 2022; Wendimu *et al*., 2024) and other developing countries (Bush *et al*., 2017; Short *et al*., 2018).

Monofilament gillnets

Illegal monofilament gillnets purchased from local markets (including Zeway and Hyk, Desse) were also commonly used. Fishers reported repeatedly dragging these nets through the river to maximise catches. Such repeated dragging can capture fish of different size classes, including juveniles, and may also disturb riverbed habitats (FAO, 2020).

Basket traps

Two types of traditional basket traps were commonly used (Fig. 4). Both are woven from plant materials and fitted with funnel-shaped entrances that prevent fish from escaping (Fig. 4a, b). The smaller trap (locally called Shatta) is installed in shallow channels modified

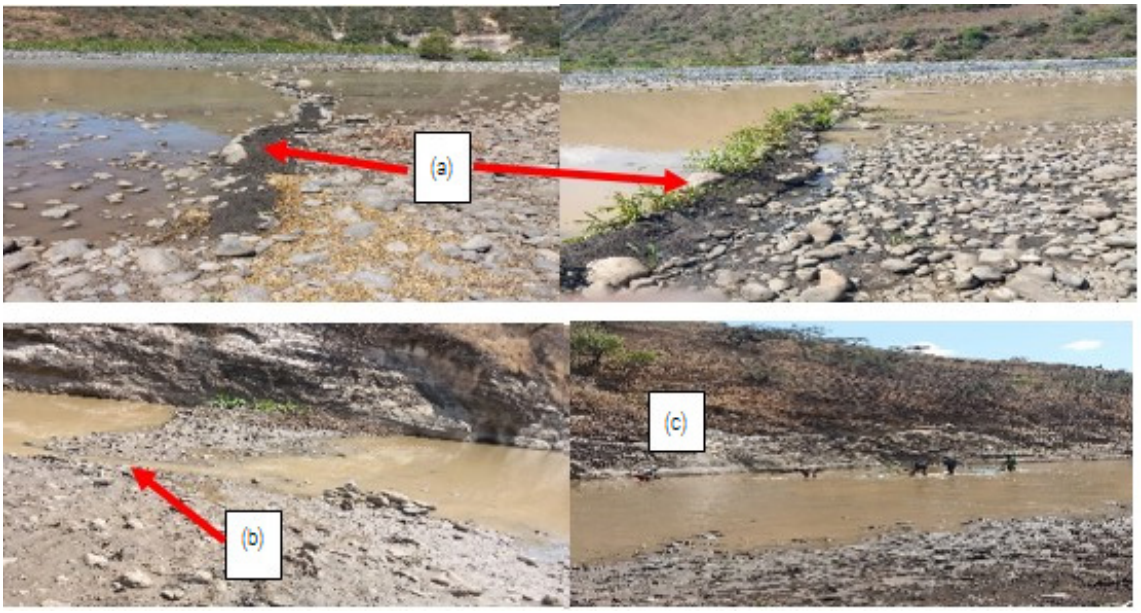

Fig. 3. River diversion and drying (Adreq) in the Jemma River. (a) Blockage of upstream flow; (b) Excavation of a drainage channel to accelerate water loss; (c) Fishers fishing using mosquito nets after water diversion

with stones and vegetation to guide fish into the trap (Fig. 4c), whereas the larger trap (Gota/Kefo) is deployed in deeper pools using bait. Field observations indicated that installation of these traps can modify shallow river sections and capture fish of different size classes, including juveniles (Fig. 4d). Prolonged and intensive use may increase juvenile mortality and affect recruitment, particularly where fishing pressure is high and effective gear regulations are absent (FAO, 2020; 2022).

Drivers behind the persistence of destructive fishing

Social and economic factors were identified as major perceived drivers of the persistence of destructive fishing in the rivers (Table 7). All respondents (100%) reported the high efficiency, low cost and easy availability of destructive fishing gears as the main reasons for their continued use. Limited access to affordable legal gears and weak market systems have similarly been reported to promote dependence on illegal and destructive fishing in Ethiopia (Mequanent *et al*., 2021; Eyayu and Getahun, 2022; Wendimu *et al*., 2024). The low cost and easy accessibility of destructive fishing gears may also be leading to increased fishing pressure by attracting additional fishers (Bush *et al*., 2017; Short *et al*., 2018). More than 90% of fishers also stated weak governance, limited awareness, lack of fishing licenses, local tolerance, and overfishing as key factors sustaining destructive fishing practices. Similar governance challenges have been reported in other small scale fisheries by Katikiro and Mahenge (2016). Poverty and livelihood dependence

Fig. 4. Traditional basket traps used by fishers in the Jemma River. (a) Small basket trap (Shatta); (b) Large basket trap (Gota or Kefo); (c) Shatta installed in a shallow channel modified with stones and vegetation to guide fish; (d) Harvesting fish trapped in Shatta; (e) Collecting fish remaining in the isolated pool using a mosquito net

Table 7. Socioeconomic factors contributing to the persistence of destructive fishing across rivers

Factors	Fishers (%)				Total	p
	Jemma	Beresa	Moferwuha	Grit		
Efficiency	100.00	100.00	100.00	100.00	100.00	–
Availability and low cost	100.00	100.00	100.00	100.00	100.00	–
Overfishing	92.57	94.29	91.43	92.86	92.73	0.933
Local tolerance	89.14	97.14	100.00	98.57	94.28	0.001*
Lack of awareness	97.71	97.14	95.71	98.57	97.40	0.740
Poverty and livelihood dependence	87.43	55.71	54.29	82.84	74.80	< 0.001*
Market demand	100.00	74.29	87.14	71.43	87.79	< 0.001*
Migrant fishers	98.28	94.29	91.43	82.86	93.51	< 0.001*
Lack of fishing licenses	94.29	100.00	100.00	100.00	97.40	0.006*
Weak governance	96.00	100.00	100.00	100.00	98.18	0.036*
Others (Conflict, Civil war)	29.71	17.14	17.14	15.71	22.59	0.025*

*Indicates significant differences among rivers in Chi-square (χ^2) test ($p<0.05$), a dash (–) indicates that the χ^2 test could not be computed because all respondents gave the same response

were additional perceived drivers, reflecting the reliance of many fishers on destructive fishing to maximise short-term catches and income (Ranjan *et al*., 2023).

Social and economic factors were identified as major perceived factors associated with the persistence of destructive fishing in the study rivers (Table 7). All respondents (100%) reported high efficiency, low cost, and easy availability of destructive fishing gears as reasons for their continued use. Limited access to affordable legal gears and weak market systems have similarly been reported to promote dependence on illegal and destructive fishing in Ethiopia (Mequanent *et al*., 2021; Eyayu and Getahun, 2022; Wendimu *et al*., 2024). The low cost and easy accessibility of destructive fishing gears may also be leading to increased fishing pressure by attracting additional fishers (Bush *et al*., 2017; Short *et al*., 2018). More than 90% of fishers also reported weak governance, limited awareness, lack of fishing licenses, local tolerance, and overfishing as factors sustaining destructive fishing practices. Poverty and livelihood dependence were additional perceived factors, reflecting respondents' reported reliance on fisheries for household livelihoods.

During KIIs and FGDs, more than 95% of participants reportedly acknowledged the continued use of destructive fishing methods. Participants described combining plant-derived or chemical toxicants with mosquito nets, monofilament gillnets, or undersised locally made nets to capture immobilised fish. They also stated that catches would be much lower without these methods. Key informants expressed concern that combining poison fishing, river drying, and illegal nets contributed to lower catches, increased capture of juveniles, and perceived stock depletion, making it harder to obtain fish for sale. These accounts indicate that socioeconomic pressures and governance limitations may contribute to the persistence of destructive fishing (Aziz *et al*., 2021; Desalegn and Shitaw, 2021).

Community awareness and initiatives to curb destructive fishing

Fishers' perceptions differed significantly among the four rivers for six of the seven Likert-scale statements (Kruskal–Wallis test, $p<0.05$), while no significant difference was found for the statement on whether previous efforts to control destructive fishing had been effective ($H=2.228$, $df=3$, $p=0.527$) (Table 8). Responses were coded from 1=Strongly agree to 5=Strongly disagree; therefore, lower median scores indicate stronger agreement with a statement. Overall, fishers agreed that destructive fishing occurs throughout the year, has increased in recent years, is sometimes used instead of other fishing gears, and that communities have limited awareness of its impacts. For the statement on Kebele-level action, the median score was 5 in all four rivers, showing strong disagreement that Kebele or village administrators had established sufficient by-laws and were actively monitoring and controlling destructive fishing. Significant pairwise differences were also found between Jemma and each of the three tributaries for this statement (adjusted $p<0.05$), indicating that fishers' perceptions of Kebele-level management differed among the rivers. Overall, the findings suggest that fishers viewed destructive fishing as a continuing and increasing problem and considered existing management and control measures insufficient. Similar observations have been reported in other small-scale fisheries, where effective management has been linked to the involvement of local communities, use of local knowledge, and stronger governance (Bennett, 2016; Katikiro and Mahenge, 2016; FAO, 2022).

Fisher's willingness and potential solutions for reducing destructive fishing

Between 90 and 100% of fishers expressed strong support for measures to reduce destructive fishing (Table 9). Fishers' support

Table 8. Differences in fishers' responses to statements concerning destructive fishing practices and management in the Jemma River and its tributaries

Item	Median (Interquartile range, IQR)				Kruskal–Wallis		Significant pairwise differences*
	Jemma	Beresa	Moferwuha	Grit	H	p	
Persistence: Destructive fishing is carried out year-round	2 (3)	1 (3)	1 (3)	1 (0)	63.481	<0.001	BR-GR, BR-JR, MR-GR, MR-JR, GR-JR
Escalation: Destructive fishing practices have become have generally increased in recent years	1 (0)	1(0)	1 (0)	1 (0)	17.384	0.001	JR-BR
Failed attempts: Efforts and measures aimed at curbing destructive fishing have not achieved the desired results	3 (2)	3 (1)	3 (1)	2 (2)	2.228	0.527	-
Government efforts: Current government measures are expected to help curb destructive fishing practices	3 (1)	3 (1)	3 (0)	3 (2)	13.728	0.003	BR-MR, BR-GR
Substitution: Destructive fishing is used instead of other fishing gears	1 (1)	1 (1)	1 (0)	1 (0)	12.267	0.007	JR-MR
Low awareness: The community has limited awareness of the impacts of destructive fishing	1 (0)	1 (0)	1 (0)	1 (0)	19.779	<0.001	JR-BR, JR-MR
Kebele action: Village or Kebele administrators have established by-laws and actively monitor and control activities to reduce instances of destructive fishing	5 (2)	5 (0)	5 (0)	5 (0)	32.197	<0.001	JR-MR, JR-GR, JR-BR

Responses were coded as 1 = Strongly agree, 2 = Somewhat agree, 3 = Undecided, 4 = Somewhat disagree, and 5 = Strongly disagree. Values are presented as median (interquartile range, IQR). Lower scores therefore indicate stronger agreement and higher scores indicate stronger disagreement. Kruskal–Wallis H tests (df = 3) were used to assess differences in response distributions among the four rivers. *Post-hoc* pairwise comparisons were conducted following significant Kruskal–Wallis tests using multiplicity-adjusted p-values at $\alpha = 0.05$. JR = Jemma River; BR = Beresa River; MR = Moferwuha River; GR = Grit River. Only statistically significant pairwise comparisons are shown

Table 9. Fishers' support for interventions to reduce destructive fishing in the study rivers

Management actions	Responses	No. of fishers				Total (%)	p
		Jemma	Beresa	Moferwuha	Grit		
Collaboration with fishers and fisheries authorities	Yes	167	64	61	60	91.43	0.043*
	No	8	6	9	10	8.57	
Fishers' participation in fisheries management	Yes	163	70	68	68	95.84	0.077
	No	12	0	2	2	4.16	
Empower local leaders to oversee fisheries management	Yes	175	66	66	68	97.40	0.018*
	No	0	4	4	2	2.60	
Training and awareness programs	Yes	175	70	70	70	100	-
	No	0	0	0	0	0.00	
Provision of authorised fishing gears	Yes	175	70	70	70	100	-
	No	0	0	0	0	0.00	
Government/stakeholder information and outreach	Yes	173	70	70	68	98.96	0.291
	No	2	0	0	2	1.04	
Stronger enforcement of fisheries regulations	Yes	168	63	60	62	91.69	0.034*
	No	7	7	10	8	8.31	
Community fishery associations/cooperatives	Yes	175	68	66	63	96.62	0.001*
	No	0	2	4	7	3.38	
Other measures (Licensing, cooperation, aquaculture)	Yes	128	27	29	17	52.21	< 0.001*
	No	47	43	41	53	47.79	

*Indicates significant differences among rivers based on the Chi-square test (χ^2), $p < 0.05$, a dash (–) indicates χ^2 could not be computed due to no variation

for collaboration with fisheries authorities, empowering local leaders, stronger law enforcement, community fishery associations, and other measures differed significantly among rivers ($p<0.05$), whereas support for fishers' participation in management and government information and outreach did not ($p>0.05$). These findings indicate substantial willingness among respondents to participate in sustainable fisheries management and highlight the potential for co-management approaches that integrate government enforcement with active community participation. Co-management approaches that combine government regulation with the participation of fishers and local communities have been shown to improve compliance, strengthen stewardship, and greater sustainability in small-scale fisheries (Gutierrez *et al*., 2011; Bene *et al*., 2016; FAO, 2022).

Although 385 fishers were interviewed, they were distributed among 11 villages, with 35 respondents selected from each village. Fishers from the same village may have shared similar environmental conditions, fishing practices, and experiences, resulting in correlated responses. Therefore, analyses based on individual respondents may overstate the effective sample size and the precision of statistical estimates. The relatively small number of villages also limited the application of more complex multilevel models. Accordingly, inferential results should be interpreted cautiously, while the reported frequencies and percentages provide a useful description of fishers' perceptions across the study area. This study found that destructive fishing practices were widely reported by fishers in the Jemma River Sub-basin. Fishers perceived these practices as persistent and increasing, while existing governance and enforcement mechanisms were considered inadequate. Respondents identified poverty, livelihood dependence, local tolerance, and weak governance, lack of licensing, market demand, overfishing, and limited awareness as important perceived factors associated with their continued use. The strong willingness of fishers to participate in management provides an opportunity for participatory and community based fisheries governance.

Sustainable fisheries management of the study area requires stronger enforcement of fisheries legislation, effective licensing systems, regular monitoring, and improved access to affordable legal fishing gears. Government and other stakeholders should strengthen local institutions, enhance awareness and training, promote community based co-management, and support livelihood diversification to reduce dependence on destructive fishing. The use of destructive fishing gears and methods should be strictly prohibited through coordinated enforcement at local, regional, and national levels. Overall, integrated, participatory, and river-specific management strategies are essential for conserving fish biodiversity and ensuring the long term sustainability of fisheries in the Jemma River Sub-basin.

Acknowledgements

The authors are thankful to all participant fishers, fisheries officials, and local government leaders for their valuable contributions, support, and cooperation during this study.

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