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Exploring Fishing Gears Efficiency: A Case Study of Fishing Crafts and Gears along the Wainganga River, Maharashtra, India

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Abstract

This extensive study, conducted along Maharashtra's Wainganga River, meticulously examined the effectiveness of diverse fishing gears employed by local fishermen. Over a year, the gathering of catch per unit effort (CPUE) data of distinct fishing gears used specifically in the lower stretches of the river. Monthly surveys were conducted across five distinct sampling sites to collect data on gear dimensions, operational methods, and building materials. The Wainganga River, known for its rich biodiversity, showcased three main fishing crafts: dug-out canoes, plank-built boats, and wooden-framed iron/tin/aluminum sheet boats. This study identified eleven distinct fishing gears commonly used in the study area, including gill nets, cast nets, dragnets, trap nets, and various types of traps and spears. Monofilament gill nets dominated year-round, while dragnets were favoured for larger catches in the summer. Despite advancements in fishing elsewhere, the preference for traditional methods persists. The selection of fishing methods depends on various factors such as fish behavior, geography, climate, and microhabitat types. Understanding these factors is crucial for the sustainable exploitation and management of fisheries resources. Overall, the study aimed to provide comprehensive knowledge about the efficiency of various fishing gears and crafts along the Wainganga River. It underscored the significance of sustainable practices for the long-term health of aquatic ecosystems and the well-being of the communities reliant on them. The study emphasized the need for adapting new technologies in small-scale fisheries and highlighted the importance of rational management and regulation.

Keywords:
Fishing gears, Wainganga river, Fishing crafts

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Introduction

Fishing is an ancient profession that involves capturing fish and other aquatic animals (Sreekrishna and Shenoy, 2001). It is a vital source of protein and provides livelihoods for rural communities (Hameed and Boopendranath, 2000). The use of various types of fishing nets and gears, differing in shapes and sizes, is vital for capturing fish of varying sizes from water bodies (Azam *et al*., 2014). Fishing gears are crafted from a diverse range of materials, such as netting, twine, plastic structural fasteners, clips, swivels, ropes, steel wire ropes, combination wire ropes, mixed fibers, polyester, polyethylene, nylon, cotton, polypropylene, floats, and sinkers, made of bamboo, wood, lead, iron, etc (Hameed and Boophendranath, 2000). Understanding fishing gears, crafts, and methods is crucial for the scientific and sustainable management of fishery resources. Fishing gears include devices of different shapes and sizes used to capture fish (Azam *et al*., 2014). Fishing methods involve the use of fishing gear and crafts to reach fishing grounds (Varun and Kamad, 2013). The choice of fishing techniques depends on fish behavior, geography, climate, and microhabitat types (Raju *et al*., 2016). Over the past fifty years, the

fishing industry has undergone significant changes, with the modernization of crafts and gears leading to increased productivity and efficiency (Khanna and Singh, 2003). Different fishing gears and techniques, such as traps, gill nets, trawls, hooks and lines, and cast nets, are used to catch fish in various water bodies (Nuhu and Yaro, 2005; Tagago *et al*., 2011; Davies and Kwen, 2012). The development of new fishing gears is influenced by seasonal variations in species variety and abundance (Bankole *et al*., 2003). Over the last fifty years, the fishing industry has undergone rapid and substantial changes, marked by the improvement and modernization of crafts and gears. These advancements have significantly increased productivity and efficiency, impacting the working conditions and lives of fishermen. Experiences accumulated over an extended period have led to the modification and improvement of fishing crafts and gears. The varied configurations of shape, size, and arrangement of fishing craft and gears in different water bodies underscore the diversity in fishing practices.

In India, the utilization of fishing crafts and gear predominantly adheres to ancient and non-mechanized practices (Khanna and Singh, 2003; Johnson *et al*., 2018). Fishing gears encompass a range of tools, including traps, gill nets, trawls, hooks and lines, seine nets, clap nets, lift nets, spears, cast nets, drift nets, entangling nets, and others, employed to catch fish from various water bodies (Nuhu and Yaro, 2005; Tagago and Ahmed, 2011; Davies and Kwen, 2012). The development of new fishing gear is influenced by seasonal variations in species variety and abundance (Bankole *et al*., 2003). The choice of gear is influenced by the habitat ecology and topography of the water body, reflecting a synergy between the environmental conditions and the intended use of the gears (Raju *et al*., 2016). Fishing gear and nets, diverse in form and size, are employed to harvest fish species of varying sizes from water bodies (Azam *et al*., 2014). The adaptation of new technologies holds the potential to enhance catch efficiency in small-scale fisheries, necessitating thoughtful management and regulation.

Comprehensive knowledge of fishing gear, crafts, and methods remains pivotal for the scientific and judicious exploitation and management of fishery resources. Riparian areas exhibit a well-defined pattern and distribution of fishing techniques, intricately linked to the topography, ecosystems, and habitat of available resources. Inland fishermen in India typically rely on traditional fishing techniques, highlighting a notable absence of detailed documentation on indigenous fishing techniques, gears, and other fishing crafts. This documentation gap is crucial for the scientific and effective management of capture fisheries (Choudhury, 1992; Koleker, 2009). The selection of fishing techniques in a specific geographic area is influenced by the distinct behavioral characteristics and microhabitats of the fish species found there (Raju *et al*., 2016). The majority of crafts and tools employed in India adhere to primitive and non-mechanized practices (Khanna and Singh, 2003). Understanding traditional fishing methods serves as a valuable foundation for enhancing modern approaches (Mundy and Campton, 1991). Therefore, the present study on fishing gears and methods aims to provide essential insights for the proper exploitation of fisheries resources, with this study specifically focusing on elucidating the efficiency of various fishing gears used along the Wainganga River.

Materials and Methods

Study area:

The comprehensive study on fishing craft and gears along the Wainganga River spanned a duration of one year, from June 2022 to May 2023. To ensure representative data, five sampling sites in the Bhandara District namely, Wangi, Dewhada BK, Dhiwarwada, Kardha, and Pauni (situated at 22°35'18"N latitude and 89°20'12"E longitude) were considerately selected based on similarities in physical habitat and accessibility. Figures 1 and 2 depicting graphical representation of the selected locations along the riverbank. The district, renowned as the district of lakes, boasts an impressive count of 3648 small lakes within its boundaries (Bisen *et al*., 2022).

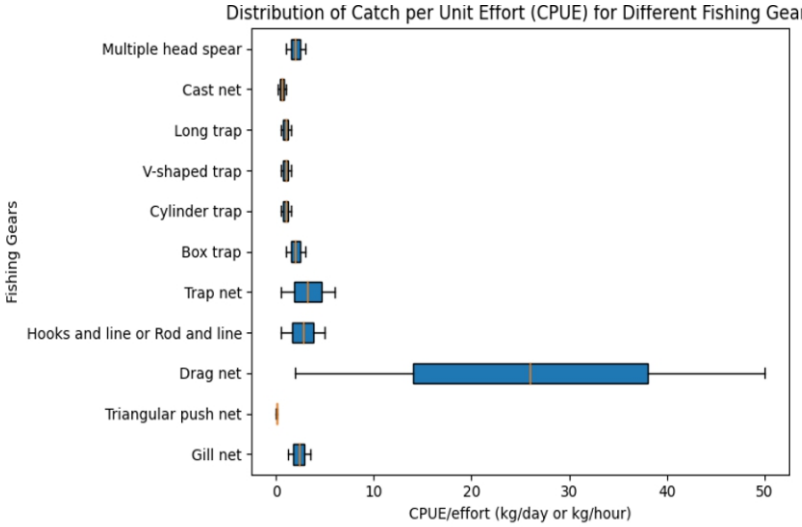

Fig. 1 Box plot depicting Catch Per Unit Effort (CPUE) for different fishing gears along the Wainganga River

Data collection:

The sampling frequency was conducted on a monthly basis, spanning up to one year. For this study, two distinct methods were employed to collect the necessary informations. Firstly, interaction-based data collection involved reaching out to local net shopkeepers and net markets. Secondly, a direct interactive field survey was conducted, incorporating personal observation along riverbanks, where measurements of length, width, height, and mesh size of various nets were taken to gather comprehensive data about operational methods and building materials were noted at each sampling site.

Results and discussion

The Wainganga River, originating in the Mahadeo Hills in Mundara near the village of Gopalganj in Seoni, Madhya Pradesh, is an important tributary of the Godavari River, which is the largest peninsular river in India. Flowing south through Madhya Pradesh and Maharashtra states, the river follows a complex course before joining the Wardha River and eventually draining into the Godavari River at Kaleshwaram, Telangana. A field study was conducted to assess the river, we identified three different types of fishing crafts and eleven distinct fishing gears commonly employed by local fishermen. Fishing nets, which are essential tools for fishing, are typically created by knotting relatively thin threads together. These nets are constructed from fibers woven in a grid-like structure. Early nets were crafted from grasses, flaxes, and other plant materials with fibrous properties. Cotton was later adopted as a primary material, however, in modern times, artificial polyamides like nylon have become the standard. However, organic polyamides such as wool or silk threads were commonly used until recently and are still utilized in some cases. The fishing crafts identified in the study included dug-out canoes, plank-built boats, and wooden-framed iron/tin/aluminum sheet boats. The various fishing gears encountered were gill nets, cast nets, dragnets, trap nets, triangular push nets, rod and line/hook and line setups, as well as multiple head spears and traps such as the 'v' shaped trap, cylindrical trap, long trap, and box trap (Table 1). Figure 1 depicting Catch per Unit Effort (CPUE) for different fishing gears along the Wainganga River. These fishing gears can be broadly categorized as either active or passive, depending on their reliance on the movement of fish (Welcomme, 1983). Passive gears, as the name suggests, do not actively move but instead rely on the natural movements of the fish to become entangled or trapped. Active gears, on the other hand, involve the deliberate movement or manipulation of the gear by the fishermen. In the case of the Wainganga River, traditional fishers were observed to utilize both active and passive gears in order to maximize their catch. River systems in India offer highly diverse habitats, and as a result, fishing methods employed in these systems vary significantly. Fishing techniques range from simple hand-catching to the operation of large, indigenous fishing nets (Saxena, 1988). The availability of trained manpower in the fisheries sector, along with the combination of traditional and modern craft and gear technologies, has contributed to increased fish production in India, including inland fish production (Hameed and John, 1996). The rapid development of fishing technology in recent years has been facilitated by advancements such as the availability of new synthetic materials, the evolution of new designs for fishing gears and crafts, and the abandonment of harmful fishing techniques driven by increased awareness. The selection of fishing methods and gears is influenced by various factors, including the physiography of the water body, the nature of fish stocks, the characteristics of raw materials used for gear fabrication, and the standard of living in the local communities (Choudhury, 1992). In this study, it was observed that all major fishing gears were self-made by fish farmers, utilizing their own knowledge and skills. In India, fishing gears and crafts used for harvesting fish have predominantly remained primitive and non-mechanized (Manna *et al*., 2011; Chakravartty and Sharma, 2013). As a result, variations in the application of fishing gear can be observed across different sampling sites, each with its own unique characteristics shaped by the specific water resources of the region.

Fishing Gears:

Gill net:

In the Wainganga River, gill nets were found to be the most commonly used fishing gear across all five surveyed sampling sites throughout the year. Local names for this net include disco jal, machhi jal, and atki jal. Gill nets are popular among fishermen due to their simplicity in construction and operation, efficiency, and low energy requirements. The nets consist of netting panels supported vertically in the water column by a head rope (float line or cork line) with floats and a foot rope (lead line) with weights. Fishermen set their gill nets in the evening and retrieve them the following morning. As passive gears, gill nets rely on the movement or migration of fish through the area where the nets are placed. The mesh of the net catches fish as they attempt to pass through it, entangling their scales, fins, or gill operculum. Smaller fish can often pass through the mesh unharmed, while larger fish are unable to navigate through it and become entangled. Fishermen are drawn to the extensive use of gill nets due to their simplicity, design, construction, and minimal investment. The size of the nets varies depending on the depth of the river, with smaller nets used in shallower areas and larger nets used in deeper parts. In the Bhandara district along the Wainganga River, gill nets with mesh sizes ranging from 16 mm to 250 mm were observed.

Triangular push net:

The traditional net known as “pelni” is primarily used for freshwater prawn fishing. It consists of three

Table 1. Comprehensive overview of fishing gears, local names, operational fishermen, species caught, season, and CPUE (Catch per Unit Effort).

Sr. no.	Fishing gear	Local name	Operational Fishermen	Species caught	CPUE/Effort	Season
1	Gill net	Disco jal, Atki jal, macchi jal, etc.	1 to 5	Indian major carps, chinese major carp, minor carp,*Sperata* spp., *Wallagu attu*, *Tilapia* spp., *Mystus* spp., etc.	0.294-1.377 (kg/man-hour)	All
2	Triangular push net	Pelni	1	Small size fish like Catfishes spp., *Labeo* spp., *Amblypharyngodon mola, Systomus sarana, Parambasis, ranga, Salmostoma bacaila* etc.	0.02-0.1 (kg/hour)	June-September
3	Drag net	Zorli jal	8 to 10	Indian major carps, chinese major carp, minor carp, Sperata spp., *Wallagu attu*, *Tilapia* spp., Eels, *Channa* spp., etc.	2.0-50.0 (kg/day)	March-May
4	Hooks and line or Rod and line	Ghri fishing	1 to 2	Tilapia spp., *Channa* Spp., *Mastacembelus armatus, Wallago attu, Sperata* spp., etc.	0.5-5.0 (kg/day)	All
5	Trap net	Kothra	2	*Puntius* spp., *Amblypharyngodon mola, Systomus sarana, Parambasis, ranga, Glosogobius giuris, Salmostoma bacaila, Ompok* spp., etc	0.50-6.0 kg/day/trap	June-September
6	Box trap	Pinjara fishing	2	*Channa* spp.,	1.0-3.0 kg/day/trap	June-September
	Cylinder trap	Kumman	1	Small size fish*Mystus* spp., *Labeo* spp., *Cirrhinus* spp., etc	0.50-1.5 kg/day/trap	June-September
	'V' shaped trap	Moude trap	2	Small and medium catfishes, barbs, *Puntius* spp. and *Danio* spp.		June-September
	Long trap	Dhir	1	Freshwater prawn, eels, *Puntius* spp.		June-September
7	Cast net	Fake Jal or bhowar jal, throw net,	1	*Sperata* spp., *Tilapia* spp.	0.2-1.0 (kg/hour)	All
8	Multiple head spear	Bhala	1	*Channa marulius, C. striata, Sperata*spp., *Cyprinus* spp., and *Wallagu attu*	1.0-3.0 (kg/hour)	April-May

bamboo triangular frames with mosquito mesh netting. One of the bamboo frame poles extends by approximately 1 meter for maneuvering the net. The net is immersed in water and moved along the bottom before being lifted. This type of net is commonly used in shallow waters with depths ranging from 0.5 to 2 meters. It is used throughout the year in various water bodies in Maharashtra, mainly for catching small fish and prawns, particularly in the shallow and marginal areas of rivers.

Drag net:

The drag net, locally known as "Zorli jal," is towed through the water surface in small or large water bodies. It requires the efforts of several fishermen due to its bulk, weight, and fine mesh (with a mesh size of 20-50 mm). Drag nets are typically used throughout the entire stretch of the river during pre-monsoon or summer months, especially when the water level is declining. They can be operated manually or with the assistance of a boat. This type of net is commonly used in lakes, reservoirs, rivers, and bays, particularly during the summer season when the water recedes. Fishermen usually avoid areas with submerged tree stumps when using drag nets.

Hook and Line/Rod and Line:

Hook and line, also known as rod and line, is one of the oldest, least expensive, environmentally friendly, and sustainable methods of fishing. It consists of a rod, a hook, and a nylon rope. The nylon line is attached to the rod on one end and to the baited hook on the other. Different types of hooks and lines are used for angling different types of fish. The lines can be fixed from the surface to the bottom, moored, or allowed to drift. Hook and line fishing is often practiced by children who assist their parents in increasing their income. Originally intended for catching a single fish, the line can be used to catch a large quantity of fish when in the form of a long line. Bait, either real or artificial, is attached to the hook to attract fish. Various baits such as wheat flour paste, sheep liver and blood, chicken guts, and earthworms are used. This fishing method can capture fish species like *Tilapia* spp., *Chana* spp., *Mastacembelus armatus*, and *Wallago attu*. For carnivorous fish, baits such as cockroaches, snails, earthworms, insects, or other small organisms are used. Hooks and bait are typically attached to the end of the line to lure fish. Hook and line fishing can be practiced throughout the year.

Trap net:

Trap net, also known as "Kothra" locally, are fishing nets with small mesh sizes that are used to create chambers to trap fish. Iron rings with a diameter of 0.4 to 0.5 meters are attached to the inner body of the net to divide it into three to four chambers. The mouth portion of the net has more free netting to lure fish into the trap, while the last section of the net gradually narrows down to function as a fish-catching funnel. Once fish enter the trap net, it becomes challenging for them to escape. Trap nets are commonly used at the outlet of river channels to catch small fish. They are considered effective and affordable compared to other traditional fishing gears. To make trap nets more selective and allow juveniles to escape, appropriate escape devices can be included.

Traps:

Fishing traps are devices that fish voluntarily migrate into and get trapped. Trap fishing is a passive fishing method with various designs, materials, constructions, and functioning alternatives that adapt to local conditions and target specific fish species based on their behaviors. Fish traps can have one or more chambers, and once the fish enter them, the chambers may be closed. Small traps, unlike large-size traps, are completely closed, resembling cages, except for the entrance. Bamboo splits are commonly used to construct traps.

Box trap:

Box traps have frames made of steel rods with dimensions of approximately 2.40 feet in length, 1.85 feet in height, and 1.85 feet in width. They consist of one-way entrance slits from opposite sides and have a bicuspid non-returning uni-directional vertical valve along the height of the trap, allowing fishes and prawns to enter. The trap is kept in a vertical position underwater, and the entrance slits close automatically. Box traps are commonly used in pre and post-monsoon seasons.

Cylindrical trap:

Cylindrical traps, locally known as "Kumman" are used by a single person to catch various fish species. This trap is used throughout the year and are particularly effective for catching small fish and prawns. Cylindrical traps help to maintain the caught fish alive.

'V' shaped trap:

The 'V' shaped trap, locally known as "Moude" is used by one person to catch a variety of fish. It is commonly used in shallow, stagnant, and calm waters, especially during the pre and post-monsoon seasons. The trap is made of wooden netting materials and strategically placed to guide fish into the trap. Once the fish enter the V-shaped opening, it becomes difficult for them to find their way out, making it easier for fishermen to catch them. 'V' shaped traps are often used to capture freshwater prawns and small fish.

Long trap:

The long trap, known as "Dhir," is a large rectangular-shaped trap with multiple horizontal pockets. It is used in shallow, stagnant, and calm waters, typically from late summer to the monsoon season. The long trap requires one or two fishermen to operate and can catch a significant number of fish in a single operation. It is effective in harvesting various small fish species and freshwater prawns.

Cast net:

Cast nets, also known as fake jal or bhowar jal, are umbrella-shaped circular nets made of nylon fibers. Cast net are used in waters with a depth of 2-3 meters. Cast net are active fish-catching tools and are thrown over the water's surface. The net is attached to a rope with sinkers along the perimeter. The mesh size of the net varies based on the size of the targeted fish. Cast nets are commonly used during the pre-monsoon months and are effective for catching small fish such as Tilapia spp., small carps, and catfish.

Multiple head spears:

Multiple head spears, locally known as "Bhala" consist of a primary pole (9 to 10 feet) with straight prongs radially connected to it using ropes. These spears require skilled fishermen to operate them. They are commonly used during the summer when the water is clear. The fisherman pushes the spear into the water in an attempt to capture large fish species such as *Channa marulius* and *C. striata.*

Fishing crafts:

Fishing crafts are movable platforms used by fishermen to operate their fishing gear. The specific types of fishing crafts used inland vary depending on the region's hydrological and topographical characteristics.

Dug-out canoe, known as "Donga" locally, is a small wooden boat carved out from a single log of wood. Sometimes, smaller canoes are constructed using palm tree trunks. These canoes are typically 3-4 meters long and 0.5-0.6 meters wide, accommodating one or two fishermen. They are commonly used in rivers for small-scale fishing, allowing fishermen to carry fish traps, gill nets, cast nets, and lines into shallow waters.

Plank-built boats, also called "Nav" or "Nauka," are constructed by joining good-quality timber planks with iron nails to form a spindle-shaped structure. The bottom of these boats is coated with coal and kerosene oil to protect against fouling and borers. They range from 5-7 meters in length and 1-1.5 meters in width. Smaller boats are used in wetlands, lakes, and tanks, while larger ones are employed in rivers and reservoirs for drag and gill net fishing. Typically, one or two fishermen operate these boats.

Wooden framed iron/tin/aluminium sheet boats, known as "Nauka" or "Donga," are wooden-framed boats covered with sheets of iron, tin, or aluminium. The sizes and shapes of these boats vary depending on their purpose and the fishing techniques employed. Commonly, these boats are 3-5 meters long and 1.5-2 meters wide, accommodating one or two fishermen. However, this type of fishing vessel is not commonly used nowadays.

Mesh size selectivity in fishing gears for sustainable fish production and conservation

The selectivity of fishing gears based on mesh size is of utmost importance for ensuring sustainable fish production and conservation (Valdemarsen and Suuronen, 2003; Wang *et al*., 2022). It has been observed that the mesh size of fishing gears can vary significantly across different locations and types of gears. Many fishermen tend to use small mesh-size gears in order to capture small-sized juvenile fish without considering their age at first maturity. These gears have the capability to retain fish fry and fingerlings, as well as fish of smaller sizes, up to larger size fishes. Unfortunately, smaller fishes are often considered undesirable and are frequently discarded by traders at these fishing sites. The selectivity of fishing gears is directly related to their mesh sizes. Different gears exhibit varying degrees of effectiveness in catching specific age classes of fish. Some gears demonstrate a strong ability to catch certain age classes of fish, while others may not be as effective. This selectivity based on mesh size plays a crucial role in determining the composition of the catch. This includes implementing appropriate catch limits and adopting mesh size selectivity measures, with a minimum mesh size of over 30 mm. Overexploitation of juvenile fish stocks can be prevented, allowing them to reach reproductive maturity and contribute to future fish populations (Caddy, 2015). Encouraging the adoption of sustainable fishing practices is necessary to ensure the long-term viability of fish populations. In addition to mesh size selectivity, it is important to enforce catch limits, implement gear restrictions, and establish closed seasons to prevent overfishing and maintain healthy fish populations. These measures help in regulating fishing activities and protecting fish stocks during sensitive periods such as breeding seasons. Furthermore, providing alternative income opportunities to poor fishermen during banned fishing periods can help alleviate the economic pressure they may face while contributing to conservation efforts. By promoting responsible fishing techniques, implementing appropriate catch limits, adopting mesh size selectivity measures, and providing alternative income opportunities, we can ensure the long-term viability of fish populations and strike a balance between fishing activities and conservation efforts.

Conclusion

The diversity of fish species and various environmental factors influence the selection of fishing gear used to exploit fish populations. Factors such as current, river depth, target fish species, and availability of raw materials contribute to the use of different fishing gears. In this context, the choice of fishing methods and gear is influenced by the physiography of the water body, the nature of fish capture, the characteristics of raw materials, and the local standard of living. Consequently, there are observed variations in the application and frequency of gear use throughout different seasons, depending on water levels, fish movement, and migration patterns. In the region under study, the prevalent fishing crafts and gears are often characterized by their primitive nature. The gill

net, particularly the monofilament gill net, is the most widely utilized gear throughout the year in the Wainganga River. However, despite advancements in fishing technology and gear in other regions, local fishermen continue to rely on traditional methods. To improve fishing practices and optimize the use of traditional and modern fishing gears, training programs for fishermen are essential. Financial support and encouragement from the government can play a pivotal role in facilitating this transition. It is crucial to prevent indiscriminate and uncontrolled fishing practices to ensure the conservation of fish stocks and maintain sustainable fisheries. The findings of this study yield valuable insights for farmers and researchers, providing a better understanding of capture and culture fisheries. Knowledge of fishing technology and techniques contributes to enhancing fish capture and fishing operations, ultimately leading to sustainable capture fishery practices. Enhancing fishing practices through the adoption of appropriate gear and sustainable techniques is essential for the long-term viability of fish populations and the development of sustainable fisheries.

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