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An Ethnomathematical Study of Conventional Fish Farming Methods: Geometric Shape and Measurement of the Pond

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Abstract**—** This Ethnomathematical study investigates the traditional geometric practices and measurement techniques employed in brackish water fish farming in Barangay Guintas, Barotac Nuevo, Iloilo, Philippines. Rooted in cultural knowledge and sustainable practices, the research explores how fish farmers utilize mathematical concept- particularly geometry and measurement- in the construction and maintenance of fish ponds. Using qualitative methods including ethnographic interviews and participant observation, the study identifies three major themes: (1) the geometric shape of the pond depends on the position and affects harvesting efficiency and water flow;(2) the pond's depth is critical for fish growth, survival, and protection from predators, with a depth of 1 meter for adult fish and 1 foot for seedlings being most effective; and (3) traditional bamboo tools are commonly used for measuring pond depth, offering a low-cost and sustainable solution for rural aquaculture. The findings highlight the value of indigenous knowledge systems in optimizing aquaculture practices and suggest practical applications for community-based resource management and environmental sustainability. This research contributes to the broader understanding of how local mathematical practices intersect with ecological resilience and food production in coastal and brackish environments.

Keywords**—** brackish water fish farming, community-based resource management, environmental sustainability, ethnomathematics, geometric practices, Iloilo Philippines , indigenous knowledge systems, measurement techniques, rural aquaculture, rural aquaculture.

I. INTRODUCTION

The fish diversity is highly newsworthy to study, most especially in terms of the inventory of fish as an effort to underscore the biodiversity of aquatic species (Hasan & Islam 2020). In the Philippines, the coastal ecosystem, with its expansive shoreline defined by mangroves and river connections, coral reefs, and seagrass communities, is home to a diverse range of fish with 3,417 species thus far identified (Froese and Pauly 2023). While most fishes evolved to dwell in either fresh or salt water due to their internal chemistry, others have developed ways to thrive in environments with moderate salinity, such as brackish water areas. These organisms of associated wetland environments are highly significant not only as dwellers of their habitats but also for regulating food web dynamics, nutrient balances, and food production.

Brackish water ecosystems, specifically, play a key role in expanding the fisheries industry by offering nursery habitats, aiding in filtering and detoxification, and serving as migratory pathways for various aquatic species, hence providing vital ecosystem services (Isroni et al. 2023). However, due to these contributing factors, they are then highly subjected to threats caused by anthropogenic activities, mainly overfishing, by-catch, and habitat modification, causing a gradual decline in their supply (Hasan & Widodo 2020) Furthermore, these anthropogenic activities have also resulted in pollution, leading to the instability of living organisms (Islamy & Hasan 2020) and promoting increased parasitism through alterations in biochemical, physiological, and behavior, specifically in nutrition, growth and production.

Fishponds come in various shapes and sizes, and understanding their dimensions is crucial for effective aquaculture. The shape and size directly impact water volume, fish stocking density, and overall pond management. Fish pond owners use various shapes in their ponds, which is much suitable with the growth of their fish. Accurate measurements are essential for calculating the pond's surface area and volume. Methods vary depending on the pond's shape. Some of pond owners vary on the size of the ponds or how much fish they may produce.

The aquaculture industry in the Philippines has historically been closely associated with milkfish culture. Traditionally, milkfish farming was primarily a brackish water operation that relied solely on tidal water exchange and the availability of natural food sources and wild-caught fry (Delmendo & Rabanal, 1956; Yashiro, 1992). Despite these rudimentary inputs, Filipino aquaculturists developed milkfish farming into a sophisticated practice characterized by elaborate pond preparation techniques aimed at fostering natural food productivity. A notable innovation was the modular method, which introduced a system of sequentially larger ponds designed to accommodate the growing fish at various life stages and to optimize the production cycle through overlapping rearing phases (Baliao, 2000; FAO, 2020).

Brackish water aquaculture offers a calculated adaptation strategy in light of climate change and the salinization of coastal agricultural areas. When managed appropriately, using underutilized brackish water areas enhances environmental sustainability and increases the productive use of natural resources. Additionally, fish farming in these regions can be combined with ecotourism and mangrove conservation initiatives to support community growth and biodiversity preservation. Fish culture in brackish water can be used as a paradigm for environmentally, economically, and aquaculture-balanced development through scientific knowledge and community involvement.

This study aims to explore and document the geometry, and measurement within conventional fish farming practices. Ethnomathematics examines the mathematical knowledge and practices embedded within specific cultures. In this context, the researcher explores how mathematical concepts are applied by fish farmers in their daily work and how these practices relate to the sustainability and efficiency of their operations. The study likely analyzes the geometric shapes and spatial arrangements used in fish farms, the measurement techniques employed for assessing fish size. It sought to answer the following questions:

- What geometric shapes allow for the most efficient use of land in pond construction?
- What is the recommended water depth for different sizes of fish? How does water depth affect the growth of fishes?
- What traditional tools are used to measure the water level of the pond?

The study documents practical methods, indigenous knowledge, and real-life experiences through the use of interviews. The study can determine the best practices currently employed in brackish water fish farming through direct discussions with practitioners. It can also pinpoint common issues including disease control, market accessibility, and water salinity management. Understanding the practical aspects that contribute to the success or failure of fish production in brackish environments requires this knowledge.

This study on brackish water fish culture holds great significance for various sectors of society, particularly for students, teachers, community leaders and policymakers, and future researchers. For students, it will facilitate the development of practical skills, while for educators, it will enhance their instructional materials. Furthermore, it will offer insights to community leaders and policymakers regarding the socio-economic advantages that can enhance fish farming operations. Lastly, it will provide a basis for future researchers in aquaculture and environmental management.Z

II. METHODOLOGY

The methodology of this study was drawn from Mallina et al (2020) about the ethnomathematical forms in fish catching activities in the Musi River, which found ethnomathematical forms in determining location, measurement, and designing using concepts such as Cartesian coordinates, sets, social arithmetic, velocity, and geometry. According to Kou and Deda, 2020 mathematics and culture is seen as a bridge from ethnomathematics. Ethnomathematics is the study of various approaches to solving mathematical problems, grounded in the diverse perspectives and cultural contexts of different communities (Budiarto et al., 2019). In this study, a qualitative research design was employed, using an ethnographic approach that included tools such as ethnographic interviews, participant observation, and field notes. These methods enabled a deeper understanding of the cultural practices of the group and the social interactions encountered throughout the research process. Qualitative research is used to describe the advantages and disadvantages of fish pond shape, the recommended water depth and what are the tools used to measure the fish pond.

The locale of the study is at Brgy. Guintas, Barotac Nuevo, Iloilo, Philippines. Before gathering the data or information needed, the Researcher secured the Permit that must be given to University, Local Officials and to the Owner or Caretaker of the Pond with duly signed persons who are responsible for conducting the study.

After giving the permit, the researcher identifies and selects participant/s that are capable and suitable for

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answering the researcher's questions that may be needed for their study. The researcher seeks for help from the Barangay Officials to identify the said participant/s.

The interview process was used after selecting the participant/s of the study. It is a method where the researcher may ask questions to the participant/s with full respect and it is the responsibility of the participants to answer the needed data or information that is needed to the study of the researchers. The researchers may use recorders, taking down notes, and documentations with the authorization of the participant/s.

After conducting the interviews, the researchers collected the responses for later analysis. The transcribed data were examined using various qualitative tools to identify themes relevant to the objectives of the study. The research employed an ethnographic approach, as outlined by Esterberg (2006), which included participating in various activities, observing while participating, taking detailed field notes, conducting both informal and formal interviews, analyzing the notes, and writing up the findings.

Limitation of the study

One limitation of this study is its restricted geographical scope, as it focused solely on fish farmers in Barangay Guintas, Barotac Nuevo, Iloilo, Philippines. As a result, the findings may not be generalizable to fish farming communities in other regions or with differing cultural and environmental contexts.

Ethical Considerations

The data were collected in an open and transparent manner, with participants treated with equal respect throughout the research process. Following the completion of data collection, the results were shared with the participants to facilitate triangulation and ensure the accuracy and credibility of the findings. This step was taken to prevent any form of misinformation or ethical misconduct, such as fabricating evidence, falsifying data, or plagiarism. To maintain confidentiality and uphold ethical standards, all collected data were securely disposed of—digital files were deleted, and physical field notes were destroyed through incineration.

III. RESULTS AND DISCUSSION

The researchers studying about Mathematics on Fish Farming summarized their findings with the following themes; (3.1) The Shape of the Pond Depends on its position, (3.2) The Depth of the Pond Helps the Growth and Survival of the Fish, and (3.3) Bamboo as use to Measure the Depth of the Ponds Water Level.

The Shape of the Pond Depends on its Position

Fish ponds are often built on farmland, and they can help increase the number of plants and animals in those areas (Ronnback et al., 2002; Walters et al., 2008). The importance of pond shape in both aesthetic and functional aspects of landscape design. They explain that irregularly shaped ponds with smooth, flowing curves tend to blend more naturally into rural environments, enhancing the visual harmony between the pond and its surroundings. Beyond appearance, the shape of a pond also plays a crucial role in practical considerations such as shoreline stability, water circulation, and wildlife support. For instance, gently sloping edges and varied contours can help reduce erosion, improve safety, and provide diverse habitats for aquatic species. Additionally, certain shapes can encourage better water movement, which helps maintain water quality and reduces stagnation. Overall, thoughtful pond design— particularly shape—is essential not only for visual appeal but also for the long-term functionality and ecological health of the pond (Russell Wright, et. Al., 2023).

Figure 1. *A square-shaped pond which is easy for fish harvesting time.*

IV. UNITS

Figure 2. *A rectangular-shaped pond.*

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Figure 3. *An aerial view of the whole pond, in which you can see the shapes of square and rectangle. (Via Google Map)*

In the study conducted, the researchers analyzed the given data gained from the participant, stating that the shape of the pond depends on its position and land area. According to the participant, "Kung square, manami siya sa isda. Bal an mo, kung magtobas ka, urot-urot, hindi palaba-laba. Pero kung palaba-laba, malayo ang isda. Mabilin sa tunga". "Bal an mo, dipende sa shape kang suba mo". "Lain sa akong nakwadrado, lapit lang akon kay nakwadrado". "Parehas sina nga nagpalaba-laba kay higad kalsada kag gin suno man sa kalsada" (the square shaped pond is good for the fish, when it is time for harvesting, it must be done little by little. If it is rectangular in shape, the fish stays in the middle of the pond. Unlike our pond it is a square-shaped pond and it is just near and they both made it long and narrow because it's beside the road and was aligned with the road). The shape of their pond is square and also rectangle; it is because of its land area wherein it is near the road and they depend it on the shape of the river which is rectangular-shaped.

A square-shaped pond benefits for the production and fish growth, making it easier for them to harvest and transport fish between ponds. The participant/s pointed out that rectangular ponds may complicate the process of harvesting because fish stays at the middle part of the pond. This observation highlights that the shape of a pond can significantly influence fish behavior and development, underscoring the importance of thoughtful pond design in achieving efficient and productive fish farming operations.

Figure 4. *A fish pond near the road, which is based on the land area.*

Figure 5. *A river that is connected to the rectangular pond wherein the river is their main source of water supply for their fish ponds.*

A pond needs to have water which the fish needs to survive. It is beneficial that the pond is near the river which will become the main source of water supply. A pond near the road is also beneficial because it was aligned with the shape of the road to avoid wasting land space. It is also easy for the owner during the harvest time; it is because they don't need to walk longer going to the road.

Ponds located near rivers and roads are good for the growth of a fish. They naturally filter dirty water, reduce pollution, and help different plants and animals live and grow. As cities and farms grow and affect water sources, using ponds in planning how land is used can be a smart and eco-friendly way to protect water quality (Mitsch, W. J., & Gosselink, J. G. (2015).

The Depth of the Pond Helps Support the Growth and Survival of the Fish

Fish naturally tend to select the habitat that is most suitable for their physiological requirements. This behavior is known as 'habitat selection' or 'enviro regulation' Mam, M. A. M., Soliman, M. A. M., & El-Gendy, A. H. (2013). Therefore, fish move into deeper water when surface water temperature decreases or increases beyond their preferred range. Fish ponds should be deep enough to meet temperature demands and other habitat requirements of cultured fish, especially in arid areas where diurnal and seasonal fluctuations in water temperature occur. Despite the vital effects of pond depth on fish growth and survival, little information is available on the subject. A depth of about 1 m is recommended for carp culture in tropical and subtropical regions (Pillay 1990). In China, a depth of 1.5 m is used for spawning tilapias, whereas 2-2.5 m depth is recommended for their rearing and wintering (Lin 1991).

In this study, the participant provided important information about the ideal water depth for various fish sizes and how water depth influences fish growth. He emphasized that "Hindi ka sa kadakuon sa punong, sa kadalumon sa tubig"(the overall size of the pond does not significantly influence fish growth. Instead, what plays a far more critical role is the depth of the water). According to the participant, "Anhon mo ang kadakuon sa punong mo kung manabaw? Kundi dali malabot na siyang pis-pis. Pero kung bisan hindi to ka dako kung madalom, mas mayo pagtubo sang isda. Bal an mo, layer-layer na sila, kapin pa kung-feeding kami. Te gatipon sa madalom ang isda" (What's the point of having a big pond if it's shallow? Birds will easily access the fish. However, even if the pond is small, its depth can be advantageous for the fish's growth. Fish tend to occupy different layers, particularly when we're feeding them. They tend to gather in the deeper areas). Deeper ponds offer crucial safety for fish, particularly from predators like birds, which are recognized for targeting smaller or surface-dwelling species, as illustrated in Figure 6. Ensuring a secure environment with sufficient water depth enables fish to thrive in a more stable and less stressful habitat, resulting in improved health and enhanced survival rates.

Figure 6: *A bird is roaming around the pond, actively searching for a fish to prey upon.*

Figure 7: *A bamboo pole labeled at 1 meter (100 cm) and 1 foot (12 inches).*

Figure 8: *The bamboo pole is placed into the pond to measure the water's depth.*

The participant utilized a tape measure to gauge the length of the bamboo pole for seedlings at 1 foot and for adult fish at 1 meter, as illustrated in Figure 7. After this, the bamboo pole was positioned vertically and placed into the pond to determine the water depth for the different stages of the fish as shown in Figure 8. Furthermore, the participant has been routinely engaging in this process for several years to uphold the health of the fish and guarantee a successful harvest.

Bamboo as Use to Measure the Depth of the Water Level of the Pond

Bamboo is a highly sustainable and renewable material that can be utilized in constructing eco-friendly aquaculture systems (Sulaiman MS. 2016). According to Boyd & Tucker (1998), "simple tools such as bamboo sticks, marked with depth intervals, are often used in traditional aquaculture systems to monitor water levels.". Measuring the depth of fish ponds is essential for effective aquaculture management.

Accurate depth data informs water volume calculations, stocking density decisions, and pond maintenance strategies (Boyd & Tucker, 1998).

While modern tools like sonar depth finders exist, traditional and sustainable materials such as bamboo poles are widely used, especially in rural or resource limited contexts. This section explores the practical application, benefits, and limitations of using bamboo in pond depth measurement.

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Figure 9: *Marked bamboo sticks are inserted vertically into the pond to visualize water levels.*

In this study, the researchers analyzed the given data gained from the participant, stating that bamboo is used to measure the depth of water level of the fish pond. According to the participant he stated that, (Gahimu kami sang dinupa nga kawayn, para sa pagtakos sang kadalumon ka tubig. Isa kadupa, isa katalok para mabal an kung pila kadupa ang kadalumon). It translated that "We make a bamboo stick, for measuring the depth of the water. One foot, one foot to know how many feet deep the water is". He uses bamboo poles or bamboo sticks that have exact measurements in inches to measure the depth of the water of the pond.

The participant shared valuable insights regarding the tool in measuring the depth of the pond, emphasizing that each bamboo is used in fish pond construction for measuring pond depth and assisting in water quality assessment because it is straight, lightweight, water-resistant, easy to mark, and readily available. According to Boyd and Tucker (1998), rural aquaculture often relies on bamboo sticks to measure and monitor pond depth, offering a simple yet efficient substitute for digital equipment. To ascertain the water depth, a bamboo stick with markings at regular intervals is inserted vertically into the pond until it reaches the bottom. The point at which the stick becomes soaked or the water line is visible signifies the current depth of the pond. After analyzing the given data, the researcher came to the conclusion that bamboo can be utilized in fish pond construction as a means of measuring pond depth and assessing water quality.

Bamboo is naturally straight, lightweight, and easy to handle. These characteristics make it ideal for use as a manual depth monitoring in fish ponds. This observation highlights that bamboo is more than just a building material; it is a practical and efficient tool for small-scale fish farmers. The practice of using traditional methods to measure pond depth and indirectly assess water quality showcases how traditional knowledge can play a crucial role in promoting sustainable aquaculture. As aquaculture continues to grow worldwide, particularly in areas with limited resources, bamboo remains a valuable asset in maintaining the health and productivity of fish ponds.

IV. CONCLUSION

In conclusion, the square-shaped pond is considered the most suitable design, as it supports the natural behavior and movement of fish, promoting better growth and well-being. The study also highlights the importance of maintaining proper water depth—about 1 meter for adult fish and 1 foot for seedlings—to ensure a stable and safe environment. The participant used traditional kawayan (bamboo) tools to monitor the water levels, reflecting sustainable local practices. This method helps protect fish from predators and supports healthy aquaculture. Overall, both pond shape and depth are the key in achieving a productive and eco-friendly fish farming system.

V. RECOMMENDATION

In the light of the findings and conclusions the following recommendations are made:

Based on the different shapes of the fish pond, aquaculture is very important and it needs concentration, time and patience to fully understand the different factors that can help to the growth of fish.

In areas with flat and unobstructed land, rectangular or square pond shapes are recommended due to their ease of construction, efficient water flow, and simplified management. These shapes are especially suitable for aquaculture, where uniformity supports feeding and harvesting practices.

A pond depth of 1 meter for adults and 1 foot for seedlings is recommended. This depth range supports adequate thermal stratification, prevents excessive temperature fluctuations, and maintains sufficient dissolved oxygen levels, which are critical for metabolic activity and immune function in fish (Boyd & Tucker, 1998).

It is recommended that small-scale farmers, aqua culturist, and environmental practitioners in resource-limited areas adopt bamboo as a reliable tool for basic depth measurement. Its availability and low cost make it especially suitable for rural communities.

To enhance accuracy, bamboo depth measurements should be combined with simple calibration methods, such as marking the stick with graduated scales (in centimeters or inches), and comparing results periodically with standardized tools when available.

Future researchers may also study about the water circulation of the fish pond in which they can identify the nutrients that the fish may gain to the water for their growth.

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