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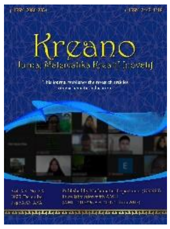

Exploring Mathematical Literacy Domains Through Banggai Yam Agricultural Practices: An Ethnographic Ethnomathematics Study

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Abstract

Ethnomathematics provides a meaningful approach to connecting mathematical concepts with learners' cultural contexts; however, empirical evidence linking agricultural practices with mathematical literacy domains remains limited. This study aims to explore mathematical structures embedded in Banggai yam farming practices and examine their relevance to mathematical literacy development. This research employed a qualitative ethnographic approach conducted in Banggai Islands Regency, Indonesia. Data were collected through participant observation, in-depth interviews with farmers and traders, and documentation of farming activities. Data were analyzed using domain, taxonomic, and componential analysis to identify cultural categories and their underlying mathematical structures. The findings reveal that Banggai yam farming involves systematic mathematical reasoning reflected in local and formal measurement systems. Farmers use traditional units such as *belek* (≈150 seed pieces) to estimate planting needs and land area, demonstrating proportional reasoning and quantity relationships. Spatial reasoning is evident in zigzag and triangular planting patterns with consistent one-meter spacing, reflecting geometric structuring and spatial optimization. Farmers also apply estimation and numerical calculations to predict yields, measure planting depth, and determine economic value using both local units and kilograms. These practices align with key mathematical literacy domains, including quantity, space and shape, and uncertainty. This study contributes to ethnomathematics by demonstrating how cultural agricultural practices embody structured mathematical reasoning and provides a culturally relevant foundation for developing contextual and culturally responsive mathematics learning.

Keywords: Ethnomathematics; Mathematical Literacy; Banggai Yam Farming; Cultural Measurement; Mathematics Education

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Abstrak

Etnomatematika menawarkan pendekatan yang bermakna untuk menghubungkan konsep-konsep matematika dengan konteks budaya peserta didik. Namun, bukti empiris yang mengaitkan praktik pertanian dengan domain literasi matematika masih terbatas. Penelitian ini bertujuan untuk mengeksplorasi struktur matematika yang terkandung dalam praktik budidaya ubi Banggai serta mengkaji relevansinya terhadap pengembangan literasi matematika. Penelitian ini menggunakan pendekatan etnografi kualitatif yang dilaksanakan di Kabupaten Banggai Kepulauan, Indonesia. Data dikumpulkan melalui observasi partisipatif, wawancara mendalam dengan petani dan pedagang, serta dokumentasi aktivitas budidaya. Data dianalisis menggunakan analisis domain, taksonomi, dan komponensial untuk mengidentifikasi kategori budaya beserta struktur matematika yang mendasarinya. Hasil penelitian menunjukkan bahwa praktik budidaya ubi Banggai mengandung penalaran matematis yang sistematis, yang tercermin dalam penggunaan sistem pengukuran lokal dan formal. Petani menggunakan satuan tradisional seperti belek (≈150 potong bibit) untuk memperkirakan kebutuhan bibit dan luas lahan, yang menunjukkan penerapan penalaran proporsional dan hubungan kuantitas. Penalaran spasial tampak pada pola tanam zigzag dan segitiga dengan jarak tanam yang konsisten sekitar satu meter, yang mencerminkan struktur geometris dan optimalisasi ruang. Petani juga menerapkan estimasi dan perhitungan numerik untuk memprediksi hasil panen, mengukur kedalaman tanam, serta menentukan nilai ekonomi menggunakan satuan lokal maupun kilogram. Praktik-praktik tersebut selaras dengan domain utama literasi matematika, yaitu kuantitas, ruang dan bentuk, serta ketidakpastian. Penelitian ini berkontribusi pada pengembangan etnomatematika dengan menunjukkan bahwa praktik pertanian berbasis budaya mengandung penalaran matematis yang terstruktur serta menyediakan landasan yang relevan secara budaya untuk mengembangkan pembelajaran matematika yang kontekstual dan responsif terhadap budaya.

INTRODUCTION

Mathematics is a fundamental discipline that plays an essential role in solving problems across various domains, including science, social sciences, medicine, and commerce (NCTM, 2000). Beyond formal academic settings, mathematical concepts are also embedded in everyday human activities, particularly within cultural practices (Papandreou & Tsiouli, 2022; Rodríguez-Nieto & Alsina, 2022). This relationship between mathematics and culture is conceptualized as ethnomathematics, which refers to the ways cultural groups understand, represent, and apply mathematical ideas in their daily lives (D'Ambrosio, 1985; D'Ambrosio, 1993). Ethnomathematics highlights that mathematical thinking is not limited to abstract symbols but is also reflected in cultural techniques, spatial organization, measurement, and problem-solving practices developed within communities.

One cultural practice that reflects ethnomathematical principles is traditional Banggai yam farming. Yams serve not only as a staple food and economic commodity but also involve structured agricultural processes such as land preparation, seed cutting, planting, and harvesting (Stuart et al., 2021; Ema et al., 2023). These practices inherently involve mathematical reasoning, including measurement, geometric arrangement, numerical estimation, and spatial organization. For example, yam tubers are cut into specific sizes (2–7 cm) and planted at regulated depths and spacing using traditional techniques such as ditugal (Aighewi et al., 2020a; Aighewi et al., 2020b). Farmers also prepare rectangular planting plots with standardized dimensions (e.g., 150 × 200 cm, 225 × 200 cm, and 300 × 200 cm), reflecting practical applications of geometry, proportional reasoning, and measurement. These structured patterns demonstrate how mathematical concepts naturally emerge within cultural and agricultural systems.

From an educational perspective, integrating cultural contexts into mathematics learning is closely linked to the development of mathematical literacy. Mathematical literacy refers to an individual's ability to formulate, apply, and interpret mathematics in real-world contexts (OECD, 2019). This includes reasoning mathematically, using mathematical concepts to solve practical problems, and interpreting quantitative information in meaningful situations. Ethnomathematics provides an effective framework for developing mathematical literacy because it connects formal mathematical knowledge with students' lived experiences (Yuliana et al., 2023; Amidi et al., 2025). When students learn mathematics through culturally relevant contexts, they are more likely to develop deeper conceptual understanding, critical thinking, and problem-solving skills.

However, current mathematics instruction often remains disconnected from students' cultural environments. In many classrooms, teachers rely primarily on standardized textbooks that lack contextual relevance to local cultural practices. Classroom observations conducted at a junior high school in Buko Selatan revealed that mathematics learning materials do not incorporate local cultural knowledge, resulting in low student engagement and limited opportunities to develop problem-solving and critical thinking skills. This condition contradicts the goals of mathematics education, which emphasize the importance of developing mathematical literacy and 21st-century competencies such as reasoning, communication, and real-world problem-solving (Kelsen, 2018; Szabo et al., 2020).

Although previous studies have documented the agricultural and nutritional characteristics of Banggai yam (Kadekoh et al., 2023; Sattu et al., 2024; Katili et al., 2025), and some research has identified mathematical activities in yam cultivation (Fang et al., 2015; Abah, 2018; Abanum et al., 2025), limited research has systematically examined how mathematical concepts embedded in Banggai yam farming can support the development of mathematical literacy within an ethnomathematical framework. Existing studies tend to focus either on agricultural aspects or general cultural practices, without explicitly linking cultural mathematical practices to mathematical literacy development in educational contexts. This gap highlights the need for research that integrates ethnomathematical analysis with mathematical literacy perspectives to support culturally responsive mathematics education.

Therefore, this study aims to explore the mathematical concepts embedded in traditional Banggai yam farming practices and examine their potential as ethnomathematical resources for supporting mathematical literacy. Specifically, this study addresses the following research questions:

1. What mathematical concepts are embedded in traditional Banggai yam farming practices?
2. How do these ethnomathematical elements support the development of students' mathematical literacy?

By identifying and analyzing mathematical concepts within Banggai yam farming, this study contributes to the development of culturally responsive mathematics learning. The findings are expected to provide a theoretical contribution to ethnomathematics and mathematical literacy research, as well as practical implications for integrating local cultural contexts into mathematics education, particularly in regions where Banggai yam farming remains an important cultural practice.

METHOD

Research Design and Approach

This study employed an ethnography of

communication research design using a qualitative approach. Ethnography of communication is used to understand, examine, and interpret social phenomena within their natural context by exploring communication patterns, cultural meanings, and practices embedded in community life (Saville-Troike, 2008; Carbaugh & Boromisza-Habashi, 2012). This design was selected because the study aims to explore mathematical concepts embedded in the cultural practices of Banggai yam farming as part of the daily life and agricultural communication practices of the Saiyong Village community. Ethnographic research enables researchers to access authentic cultural practices, obtain rich contextual data, and understand how knowledge is constructed and transmitted within a cultural group.

This study applied a qualitative approach to understand the meaning of farming practices based on participants' perspectives and lived experiences. Qualitative research allows the collection of detailed narratives expressed naturally according to participants' language, interpretations, and cultural viewpoints (Lim, 2025). Through this approach, the study sought to capture cultural knowledge related to measurement systems, spatial arrangements, estimation practices, and traditional agricultural calculations used in Banggai yam farming.

The data analysis process followed ethnographic analysis stages adapted from Spradley (1979), which include identifying social situations, conducting participant observation, recording observational and interview data, performing descriptive observation, domain analysis, focused analysis, taxonomic analysis, componential analysis, thematic analysis, identifying cultural findings, and preparing the research report. These stages enabled systematic identification of cultural patterns and ethnomathematical practices embedded in farming activities.

Research Site

This research was conducted in Saiyong Village, Tinangkung District, Banggai Islands Regency, Indonesia, from May to July 2024. Saiyong Village was selected because its community actively practices traditional Banggai yam farming, which remains an important cultural and economic activity. The village provides a relevant cultural setting for examining mathematical practices embedded in traditional agricultural systems.

Field data collection was carried out intensively from July 22 to July 26, 2024. Prior to data collection, the researcher submitted a formal research permit to the village administration through the village secretary. After obtaining permission, the researcher conducted field observations and interviews with yam farmers and community members involved in Banggai yam cultivation and distribution.

Participants

Participants were selected using purposive sampling, based on their direct involvement, experience, and knowledge of Banggai yam farming practices. The selection criteria included individuals actively engaged in yam cultivation, trading, or possessing extensive cultural knowledge related to Banggai yam agriculture.

A total of four informants participated in this study, consisting of farmers and a trader. Their profiles are presented in Table 1.

Table 1. Participant Profile

Code	Name	Role	Occupation
P1	Mr. Abdullah	Farmer and Head of Hamlet (Kadus 2)	Farmer and community leader
P2	Mr. Urim	Farmer and Head of Hamlet (Kadus 4)	Farmer and community leader
P3	Mr. Hamran	Farmer	Supporting informant
P4	Mrs. Atik	Yam trader	Supporting informant

The key informants (P1 and P2) were selected because of their extensive farming experience and leadership roles in the community, which enabled them to provide detailed information regarding planting systems, measurement practices, agricultural estimation, and traditional farming knowledge. Supporting informants provided additional perspectives regarding farming practices and marketing systems.

Research Procedure

The research began with administrative preparation, including obtaining permission from local authorities. Following approval, the researcher conducted participant observation by visiting farmers' homes and agricultural fields to observe Banggai yam farming activities. These observations focused on land preparation, planting methods, measurement systems, and harvesting practices.

Interviews were conducted in two stages. The first interview session took place on July 23, 2024, with P1 (Mr Urim) from 10:00 to 11:30 WITA and P2 (Mr Abdullah) from 13:00 to 14:00 WITA. The second interview session was conducted on July 24, 2024, with P3 (Mr Hamran) from 09:00 to 10:30 WITA and P4 (Mrs Atik) from 19:30 to 20:30 WITA. Interviews were conducted in a semi-structured format, allowing participants to explain their farming practices, measurement systems, and traditional agricultural knowledge in detail.

During observation and interviews, the researcher also collected documentation in the form of photographs, field notes, and records of farming tools, planting arrangements, and measurement practices. Some limitations were encountered during fieldwork, including the fact that some yam harvesting had already been completed and agricultural fields were located outside the village, requiring additional travel time to reach the farming locations.

Data Collection Techniques

Data collection in this study employed participant observation, in-depth interviews, documentation, and data triangulation to ensure comprehensive and credible ethnographic findings.

Participant observation was conducted as a primary ethnographic method to enable the researcher to directly engage with the community and observe Banggai yam farming practices within their natural cultural setting. Participant observation is a traditional method in ethnographic research that allows the researcher to enter the social environment of the participants, observe their activities, and understand cultural meanings and behavioral patterns from an insider perspective (Delamont, 2004). During this process, the researcher visited Saiyong Village and observed farming activities, land preparation, planting processes, harvesting practices, and interactions among farmers. The researcher also observed how farmers estimated land area, determined planting distances, counted seedlings, and organized farming activities. These observations enabled the researcher to understand how mathematical reasoning is embedded in everyday agricultural practices and helped provide contextual data to complement interview findings.

In-depth interviews were conducted to obtain detailed and objective information regarding Banggai yam farming practices and their cultural meanings. Ethnographic interviews are typically unstructured or semi-structured, allowing participants to explain their experiences using their own terminology and perspectives (De Fina, 2019). This approach allows participants to define their practices and cultural knowledge naturally without being restricted by predetermined answer options. Interviews were conducted in an informal and conversational manner to create a comfortable environment and encourage open communication. The interviews focused on farming activities, including land measurement, seed preparation, planting patterns, harvesting estimation, and marketing systems. This method enabled the researcher to explore participants' reasoning processes, estimation techniques, and traditional knowledge systems related to ethnomathematical practices.

Documentation was used to support and strengthen the data obtained through observation and interviews. Documentation involved collecting photographs, field notes, and recordings related to farming tools, planting arrangements, measurement activities, and agricultural environments. Visual documentation provided additional evidence of traditional measurement systems, spatial arrangements, and farming patterns used by the community. These materials helped ensure the accuracy of observational findings and supported the interpretation of ethnomathematical practices.

Data triangulation was applied to ensure the credibility and validity of the research findings. Triangulation is a technique used to verify data accuracy by comparing information obtained from different sources, methods, or perspectives (Donkoh & Mensah, 2023). This study employed source triangulation by comparing information obtained from multiple informants, including farmers and traders. The researcher also compared data obtained from observation, interviews, and documentation to ensure consistency and reliability. This triangulation process strengthened the trustworthiness of the findings and ensured that the identified ethnomathematical practices accurately reflected the cultural realities of the community.

Research Instruments

The primary instrument in this study was the researcher, who was directly involved in observing, interviewing, recording, and interpreting the data. In qualitative ethnographic research, the researcher serves as the main instrument because of their ability to interact with participants, interpret cultural meanings, and understand social contexts.

Supporting instruments included observation sheets, interview guidelines, and documentation tools such as a mobile phone for recording audio and capturing photographs. The observation sheet was used to guide the researcher in observing farming activities systematically. The observation indicators included field conditions, land characteristics, and community activities; planting practices such as types of yam, planting tools, planting patterns, planting distances, and planting methods; and harvesting processes, including harvesting techniques and crop yield.

The interview guideline was designed to explore participants' knowledge and experiences related to Banggai yam farming. The interview indicators included historical aspects such as the history and development of Banggai yam farming, cultural practices, and agricultural knowledge; planting aspects such as land size, planting time, number of seedlings, planting tools, planting distance, and planting methods; harvesting aspects such as harvesting time and crop yield; and marketing aspects such as distribution systems and selling prices.

These instruments ensured systematic and comprehensive data collection and enabled the researcher to identify mathematical concepts embedded in Banggai yam farming practices.

Data Analysis Technique

Data analysis in this ethnographic qualitative study was conducted using three stages of cultural theme analysis, namely domain analysis, taxonomic analysis, and componential analysis (Indra et al., 2024). These stages were used to systematically identify, organize, and interpret cultural meanings embedded in the Banggai yam farming practices.

The first stage was domain analysis, which aimed to obtain a general and comprehensive overview of the research object and the social situation being studied. At this stage, the researcher analyzed data obtained from participant observation, interviews, and documentation to identify broad categories or domains related to Banggai yam farming practices. The researcher used general and descriptive questions to explore participants' experiences, activities, and cultural knowledge. This analysis provided an initial framework for understanding the cultural context and identifying key domains relevant to ethnomathematical practices.

The second stage was taxonomic analysis, which aimed to examine the internal structure of each identified domain in greater detail. In this stage, the researcher organized and classified data into subcategories based on similarities, relationships, and patterns found within each domain. This analysis helped reveal how Banggai yam farming practices are structured, including planting systems, spatial arrangements, measurement practices, and harvesting processes, and how these reflect implicit mathematical concepts embedded in cultural activities.

The final stage was componential analysis, which aimed to identify specific characteristics and distinctions between elements within each domain. This analysis involved comparing and contrasting data obtained from observations and in-depth interviews to uncover unique features, meanings, and relationships between cultural practices and mathematical concepts. Through this process, the researcher was able to interpret the underlying cultural logic and ethnomathematical knowledge embedded in Banggai yam farming practices.

Through these three stages of analysis, the study was able to identify cultural themes and provide a comprehensive understanding of how mathematical concepts are embedded in the traditional agricultural practices of the Banggai community.

RESULT AND DISCUSSION

Results

Land Preparation and Use of Local Measurement Systems

Land preparation represents the initial stage of Banggai yam cultivation. Farmers perform an activity locally known as *balokomi*, which refers to clearing vegetation and preparing land for planting. This process is commonly conducted through a traditional mutual cooperation system called *polobuku* or *polai-lai*, where community members assist each other in agricultural work. This collective practice enables farmers to prepare land more efficiently while maintaining cultural traditions of cooperation. As explained by P1:

"Before planting, we do balokomi, clearing the land together. Usually people help each other through polobuku, so the work becomes easier and faster."

Farmers determine planting areas based on land fertility, sunlight exposure, and planting needs. The size of cultivated land typically ranges from approximately ½ hectare to 1 hectare. Land area estimation is closely related to the number of seedlings prepared and the planned planting arrangement, particularly when intercropping is applied. Farmers use both formal and informal measurement systems in this process.

Formal measurement units such as hectares are used to express land area, where one hectare equals 10,000 square meters. However, farmers also rely on local measurement units to estimate planting capacity. One commonly used unit is *belek* (also called *bois*), a traditional container used to measure yam seedlings. Each *belek* contains approximately 150 seed pieces known locally as *tongol* or *tebe*. This unit helps farmers estimate planting requirements and land coverage. As explained by P2:

"We usually measure seedlings using belek. One belek contains about 150 tongol. From there we know how much land can be planted."

In addition to land and seed measurement, farmers also apply traditional knowledge to determine planting time. The appearance of the *Paliama* constellation, locally known as the "Seven Stars," serves as a seasonal indicator signaling the appropriate time to begin planting. This practice reflects the integration of cultural knowledge with agricultural decision-making.

These findings indicate that land preparation involves both formal measurement concepts, such as area units (hectares), and informal measurement systems, such as *belek* and estimation practices. These local measurement systems allow farmers to manage planting activities effectively without relying entirely on standardized measuring instruments.

Table 2 presents observed land preparation activities and related measurement practices.

Table 2. Land Preparation Activities and Mathematical Elements

Activity	Traditional Method	Local Measurement	Observed Quantity	Potential Mathematical Elements
Land clearing (*balokomi*)	Parang, manual labor	Estimation using belek and tongol	± ½ – 1 hectare	Area measurement, estimation, unit conversion
Soil preparation	Wooden stick (*suan*)	Hole depth estimation	±10 cm depth	Length measurement
Seed estimation	Belek container	1 belek ≈ 150 tongol	10 belek ≈ ½ hectare	Ratio, proportion

Measurement Practices in Seed Preparation and Planting

Measurement practices were consistently observed during seed preparation and planting activities. Farmers prepare planting material by cutting yam tubers into smaller pieces known locally as *tongol*. These seed pieces have relatively uniform dimensions to ensure optimal growth. Informants explained that the length of each seed piece generally ranges from 7 to 9 cm, while the width is approximately 5 cm. This indicates that farmers apply practical measurement considerations to maintain seed quality and viability. As P1 explained:

"Usually we cut the seed about 7–8 cm so it grows well and evenly."

Field observations further showed that a single yam tuber can produce approximately 15–20 seed pieces. Farmers also use traditional measurement units to estimate planting needs. The local unit *belek* is used as a seed measurement and storage unit, where one *belek* contains approximately 150 seed pieces. Farmers explained that about 10 *belek*, or approximately 1,500 seed pieces, are required to plant around half a hectare of land. This traditional unit enables farmers to estimate planting requirements efficiently without relying on formal numerical calculations.

Measurement is also evident during land preparation, particularly in determining planting hole depth and spacing. Farmers use a traditional wooden tool called *suan*, a sharpened wooden stick, to create planting holes. Observations indicated that the holes are approximately 10 cm deep and are prepared systematically to ensure uniform planting conditions.

In addition, farmers apply consistent distance measurement between seedlings. Informants reported that yam seedlings are planted approximately 1 meter apart to ensure sufficient growing space and optimal yield. Instead of using formal measuring instruments, farmers rely on practical estimation methods such as using wooden sticks or foot-length estimation. As expressed by P2:

"We use the distance of about one meter between plants so the yam has enough space to grow."

These findings demonstrate that farmers apply informal but systematic measurement practices using local units, estimation techniques, and practical tools. Such practices reflect embedded mathematical understanding in agricultural activities, particularly related to length measurement, unit conversion, and spatial arrangement.

Table 3. Seed Measurement and Planting Distance

Local Unit	Equivalent Quantity	Use
1 tongol	1 yam seedling	Planting unit
1 belek	±150 tongol	Seed storage and measurement
10 belek	±1500 tongol	Land estimation
Planting distance	±1 meter	Distance between seedlings

Spatial Arrangement and Planting Pattern Practices

Farmers apply specific spatial arrangements when planting Banggai yam to ensure optimal plant growth and efficient land use. Informants explained that seedlings are planted using a zigzag or triangular pattern, with approximately 1 meter spacing between plants. This arrangement allows each plant to receive sufficient sunlight and provides adequate space for vine development.

Observation results confirmed that farmers maintain relatively consistent spacing through estimation methods, often using body-based measurements such as foot length or visual approximation. This practice reflects the application of informal measurement systems in spatial organization. As explained by Informant P2:

"We do not plant in a straight line. The position is alternating so each plant has enough space to grow properly."

From a spatial perspective, this arrangement forms a triangular planting pattern. This pattern allows more efficient land coverage compared to simple linear arrangements and reflects an intuitive understanding of spatial distribution and density.

In addition to spacing, farmers install support poles locally known as *boloi*. These wooden stakes are placed beside each yam plant to support climbing vines. Farmers apply a one-to-one correspondence principle, where each plant requires one *boloi*. As explained by Informant P3:

"Each yam plant must have one boloi to support the vine. So if we plant 1,500 seedlings, we also prepare 1,500 boloi."

This practice demonstrates the use of numerical correspondence and counting principles in agricultural management. The relationship between the number of plants and the number of support poles reflects practical applications of one-to-one matching and quantity estimation.

Table 4 Planting Pattern and Spatial Arrangement

Pattern Type	Description	Distance	Estimated Density
Linear pattern	Straight row planting	±1 meter	±10,000 plants/hectare
Triangular pattern	Zig-zag arrangement	±1 meter	±3 plants/m²

Numerical Practices in Harvesting and Yield Estimation

Harvesting of Banggai yam typically occurs between 7 and 12 months after planting, depending on plant maturity. Farmers determine harvest readiness based on visual indicators, particularly when leaves begin to yellow and dry. These visual observations serve as practical indicators guiding harvest timing.

Farmers apply numerical estimation practices to predict harvest yield and manage agricultural production. Informants explained that yield estimation is based on the number of planted seedlings and previous harvest experience. For example, approximately 1,800 yam plants can produce up to 3 tons of harvest yield under favorable conditions. As explained by Informant P1:

"If we plant around 1,800 yam plants, usually we can harvest about three tons, depending on the growing conditions."

These estimations help farmers plan storage, allocate seed for future planting, and determine the quantity available for market sale. Farmers also categorize harvested yam into several functional groups, including yam for household consumption, yam reserved as seed, and yam intended for sale.

Traditional measurement units are also used in trading and storage. The *belek* serves not only as a planting measurement unit but also as a unit of storage and local trade. This reflects the integration of numerical concepts with economic activities.

Table 5. Harvest Estimation and Distribution

Unit	Equivalent	Use
1 tongol	1 yam seedling	Plant unit
1 belek	Seed container	Storage
Harvest yield	±3 tons per cycle	Production measurement
Price per kg	Rp12,000	Market value
1 belek value	Rp150,000	Local trading unit

Economic and Marketing Practices Using Local and Formal Numerical Systems

Mathematical practices are clearly reflected in the economic and marketing activities of Banggai yam. Informants explained that yam is sold using both traditional local units and formal standard units such as kilograms. This dual measurement system demonstrates the integration of culturally rooted numerical systems with formal market-based measurement practices.

One of the most commonly used traditional units in marketing is the *belek*, which functions as both a storage and trading unit. Farmers and traders use this unit to simplify counting and pricing without requiring weighing instruments. As explained by Informant P4, who works as a yam trader:

"Usually we buy and sell using belek. One belek is around one hundred fifty thousand rupiah, depending on the size and quality."

In addition to local units, yam is also sold using formal weight measurements, particularly when traded in larger markets. Informants reported that the farm-level price is approximately IDR 12,000 per kilogram, with higher prices possible in urban markets. The use of kilograms allows traders to standardize transactions and align with broader market systems. Informant P4 further explained:

"If it is sold in the market, sometimes we use kilograms. The price is around twelve thousand rupiah per kilogram, but it can increase depending on demand."

Mathematical practices are also evident in harvest distribution systems. One traditional sharing system known as *mansabol* regulates the distribution of harvest yields between landowners and cultivators. This system involves proportional division based on prior agreements, reflecting the application of ratio and proportional reasoning in economic exchange.

Observation results also confirmed that yam distribution occurs through multiple channels, including direct sales at farms, roadside stalls, and local markets. In addition to commercial transactions, yam is sometimes distributed within the community as part of social exchange practices. This reflects the integration of economic calculation with social and cultural values.

Discussion

Cultural Farming Practices as Domains of Ethnomathematical Knowledge

Based on the domain analysis, Banggai yam farming practices represent a cultural domain containing embedded mathematical knowledge expressed through everyday agricultural activities. These include land preparation (*balokomi*), seed preparation using local units such as *belek* and *tongol*, spatial planting arrangements, and yield estimation and marketing. These activities are not formally recognized by farmers as mathematical processes; however, they reflect systematic quantitative reasoning developed through cultural experience.

This finding supports Barton's (1996) argument that ethnomathematics exists as mathematical practices embedded within cultural activities and expressed through culturally specific representations. In this study, mathematical ideas such as measurement, estimation, and spatial structuring emerge from practical needs rather than formal schooling. Farmers use measurement systems such as hectares and meters alongside local measurement units such as *belek*, demonstrating the coexistence of formal and informal mathematical systems. This hybrid measurement system illustrates how mathematical thinking develops as an adaptive cultural response to environmental and economic demands.

Similarly, Gerdes (1994) emphasized that mathematical thinking evolves through cultural practices related to survival, production, and social organization. In Banggai yam farming, farmers use measurement and counting to ensure efficient land use, proper plant spacing, and optimal yield estimation. These mathematical practices emerge from repeated interaction with the natural environment, demonstrating that mathematical reasoning is culturally constructed and functionally embedded within agricultural life.

Structural Relationships Between Farming Activities and Mathematical Concepts

Taxonomic analysis revealed that Banggai yam farming practices contain structured mathematical relationships, particularly in measurement, spatial reasoning, proportional reasoning, and numerical estimation. For example, farmers use a consistent planting distance of approximately one meter between seedlings, creating spatial arrangements that form triangular or zigzag patterns. These patterns reflect geometric structuring and spatial optimization strategies.

From an ethnomathematical perspective, this spatial organization reflects what Rosa and Orey (2011) describe as culturally situated mathematical practices, where mathematical structures emerge from problem-solving processes within specific cultural contexts. Farmers do not explicitly describe their planting pattern as geometric triangulation; however, their practice reflects an implicit understanding of spatial efficiency, symmetry, and distribution.

Componential analysis further revealed contrasts between formal and informal measurement systems. Farmers use informal tools such as wooden sticks and body-based measurement (foot length) to approximate one-meter distances. This reflects embodied mathematical cognition, where mathematical reasoning is mediated through physical experience rather than abstract symbolic systems. Such embodied measurement practices align with Gerdes' (1999) observation that traditional societies often develop practical geometric reasoning through physical interaction with their environment.

These findings also align with mathematical literacy domains defined by the Programme for International Student Assessment (PISA), particularly: (1) quantity, reflected in counting seed units (*tongol*) and estimating yields and prices; (2) space and shape, reflected in triangular planting patterns and spatial land organization; and (3) uncertainty and data, reflected in yield estimation, harvest timing, and agricultural planning

Thus, Banggai yam farming practices demonstrate multidimensional mathematical literacy embedded in cultural practice.

Cultural Reasoning and the Emergence of Mathematical Structures

The emergence of mathematical structures in Banggai yam farming is closely linked to cultural reasoning shaped by environmental adaptation, efficiency, and collective knowledge transmission. Farmers developed local measurement systems such as *belek* because these units provide practical and efficient ways to organize seed quantities without requiring formal weighing tools.

Similarly, triangular planting patterns emerge as a culturally refined spatial strategy to maximize land productivity while allowing sufficient space for plant growth. This demonstrates adaptive mathematical reasoning driven by ecological constraints and agricultural efficiency rather than abstract mathematical theory.

This finding supports Bishop's (1988) argument that fundamental mathematical activities—including counting, measuring, locating, designing, and explaining—are universal human activities shaped by cultural context. In Banggai yam farming, these mathematical activities are expressed through culturally meaningful systems that integrate environmental knowledge, economic needs, and social cooperation.

Furthermore, ethnography of communication analysis revealed that mathematical knowledge is transmitted orally and through practice, rather than through formal instruction. Farmers learn measurement systems, planting patterns, and estimation techniques through observation, participation, and intergenerational communication. This supports Barton's (2008) view that mathematical knowledge exists within cultural communication systems and social interaction.

Implications for Mathematics Education and Culturally Responsive Pedagogy

The findings of this study have important implications for mathematics education, particularly in supporting culturally responsive pedagogy. Banggai yam farming provides authentic cultural contexts that can be used to teach mathematical concepts such as measurement, geometry, ratio, estimation, and financial arithmetic.

Integrating ethnomathematical contexts into mathematics education can improve students' mathematical literacy by connecting abstract concepts with familiar cultural practices. Rosa and Orey (2016) argue that culturally responsive mathematics education enhances student engagement and conceptual understanding by validating students' cultural experiences as legitimate sources of mathematical knowledge.

For example, teachers can use planting distance to teach measurement and geometry, seed counting to teach ratio and proportion, and marketing practices to teach financial mathematics. These culturally grounded examples help students understand mathematics as meaningful and applicable to their daily lives.

This approach aligns with contextual learning theory (Kolb, 1984), which emphasizes that knowledge is constructed through experience. It also supports mathematical literacy development by enabling students to apply mathematical reasoning in real-world situations.

Furthermore, incorporating ethnomathematics into curriculum design promotes cultural preservation by recognizing traditional knowledge as an important intellectual resource. This helps bridge the gap between school mathematics and community knowledge systems.

Contribution to Ethnomathematics Research

This study contributes to international ethnomathematics research by documenting mathematical practices embedded in Banggai yam farming, which remains underrepresented in ethnomathematics literature. While previous studies have documented ethnomathematical practices in architecture, weaving, and craft traditions, agricultural ethnomathematics remains less explored, particularly in Southeast Asia. This study extends the work of Gerdes, Barton, and Rosa and Orey by demonstrating how mathematical reasoning emerges from agricultural systems involving land measurement, spatial organization, and economic exchange.

Limitations of the Study

This study has several limitations. First, the number of participants was limited to key informants, which may not fully represent the diversity of mathematical practices across all farmers in the region. Second, the study focused on one village, limiting the generalizability of findings to other cultural contexts. Third, as an ethnographic study, findings rely on participant observation and self-reported information, which may be influenced by participant memory or interpretation. Additionally, the study focused primarily on observable practices and did not quantitatively measure the accuracy or efficiency of traditional measurement systems.

Directions for Future Research

Future research should involve a larger number of participants across multiple villages to explore variations in ethnomathematical practices. Comparative studies between different agricultural communities would provide deeper understanding of how mathematical knowledge develops across cultural contexts.

Future studies should also explore how ethnomathematical knowledge can be systematically integrated into school curricula and evaluate its impact on students' mathematical literacy and learning outcomes. Additionally, interdisciplinary research combining ethnomathematics, education, and cognitive science could further examine how cultural practices influence mathematical thinking and learning.

CONCLUSION

This study found that Banggai yam farming practices contain embedded mathematical concepts that emerge from culturally rooted agricultural activities. Through ethnographic exploration, mathematical ideas were identified in land measurement using hectares and local units such as *belek* and *tongol*, spatial reasoning through triangular and zigzag planting patterns with one-meter spacing, quantitative reasoning in estimating seed quantity and yield, and financial arithmetic in pricing and marketing systems. These practices demonstrate that mathematical knowledge is culturally constructed and functionally applied in everyday farming activities.

Furthermore, the findings show that Banggai yam agriculture provides meaningful ethnomathematical contexts that align with key mathematical literacy domains, including quantity, space and shape, and proportional reasoning. This confirms that local agricultural culture can serve as a relevant and authentic resource for mathematics learning, supporting culturally responsive pedagogy and helping students connect formal mathematical concepts with real-life experiences.

These results highlight the potential of integrating ethnomathematical knowledge from Banggai yam farming into mathematics education to enhance students' conceptual understanding, mathematical literacy, and cultural awareness.

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