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STEM Analysis (Science, Technology, Engineering and Mathematics) of the Agricultural System of the Indigenous People of Urug Village

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Abstract: This study examines the potential of STEM in the context of indigenous farming systems in Urug Village to improve agricultural sustainability, increase crop yields, and promote environmental conservation through education. Surveys and data collection to identify challenges and opportunities, and to develop solutions that meet the needs of indigenous communities while prioritizing sustainability and environmental conservation are practical steps for this study. Data was collected from the agricultural practices of the Urug indigenous community using the survey method, which included participatory observations, interviews, literature reviews, and documentation. Technical terms are explained upon first mention. The Urug indigenous community follows a series of rice planting procedures. These include babad susukan, seed preparation, seed soaking for two days, stocking, ngabaladah, babad, mingul, ngangler, tandur, ngoyos, ngadares, dibuwat (harvest), lantayan, and ngunjal. The study of science in the community centers around concepts such as astronomy, ecosystems, simple aircraft, pressure, temperature, and heat. Additionally, simple technologies such as terracing, etem, and leuit are employed. Agricultural engineering focuses on environmentally friendly rice farming. Mathematics deals with numbers and operations used in solving numeric problems, as in the calculation of the Pranatamangsa calendar and the Tandur. This agricultural knowledge can be integrated into STEM education.

Keywords: Agriculture system; Indigenous people; STEM; Urug village

Introduction

Indonesia is recognized as an agricultural nation, where agriculture serves a significant function in its domestic economy. It is the primary source of livelihood for the populace, with customary practices including small-scale farming, forestry, livestock breeding, and fisheries. In 1970, the Indonesian government adopted the Green Revolution, which introduced modern agricultural practices heavily dependent on chemical fertilizers and pesticides (Marianto et al., 2023). Nevertheless, the adverse impacts of these practices on ecosystems and pollinating insects have raised concerns (Ningrum et al., 2023). It is worth noting that the Green Revolution is not universally practiced by all Indonesian farming communities. One indigenous community that diverges from this norm is the Urug indigenous community in Urug village, located within the Bogor region of West Java, Indonesia. One indigenous community that diverges from this norm is the Urug indigenous community in Urug village, located within the Bogor region of West Java, Indonesia.

The community's economy heavily relies on agriculture. Their agricultural system differs from that of

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Indonesian society at large, as it remains rooted in ancestral knowledge passed down between generations. Indigenous knowledge, rooted in centuries of experience and tailored to local culture and environment, is a valuable asset for advancing sustainable development and making informed decisions in a variety of fields (Maraña et al., 2023). The agricultural system of the Urug indigenous people has enabled them to achieve self-sufficiency in rice. The Urug indigenous people's agricultural system should be studied to establish food security. Conducting a STEM review is one possible approach.

STEM, which represents Science, Technology, Engineering and Math, is an emerging educational movement that promotes innovation. STEM is an approach to learning that integrates four disciplines, aiming to enhance students' abilities in problem solving, critical thinking, and creativity. The STEM approach meets the appropriate criteria for student learning and can improve their scientific process skills (Syukri et al., 2021). It fosters skills such as scientific thinking, reasoning, logical analysis, effective communication, and collaboration to prepare students for the demands of the 21st century (Buber & Coban, 2023). STEM projects entail conducting experiments, solving real-world issues, making advancements, and exploring new applications in these fields. Table 1 provides an overview of the benefits of STEM as outlined below.

Table 1. Previous Research on STEM Education

Title	Topic discussion	Ref
Interdisciplinary and Integrated STEM	STEM education is an innovative approach that is recognised internationally. When integrated and interdisciplinary, STEM has the potential to generate powerful knowledge.	(Kurup et al., 2021)
The importance of the mathematical modeling in stem education	STEM education is an interdisciplinary model that aims to develop essential skills and knowledge in students, with a focus on science, technology, engineering, and mathematics.	(Tuneski, 2022)
Science, Technology, Engineering, and Mathematics (STEM) as A Learning Approach to Improve 21st Century Skills: A Review	STEM approach fosters critical thinking, creativity, communication, and collaboration skills.	(Fajrina et al., 2020)
The Development of Teaching Material Based on Science, Technology, Engineering, and Mathematics (STEM)	STEM is the approach to education that integrates science, technology, engineering and maths to develop critical thinking and problem solving.	(Rahman et al., 2021)
To STEM or not to STEM? That is not the question	STEM education is an interdisciplinary approach. It promotes the development of critical thinking and problem-solving skills.	(Kubat & Guray, 2018)

STEM analysis in the context of native agricultural systems in Urug Village may offer a crucial opportunity to advance agricultural sustainability, enhance crop yields, and safeguard the environment through an instructive approach. Practical steps for this study might comprise conducting surveys and collecting data, identifying challenges and opportunities, and devising solutions that address the requirements of the indigenous community while adhering to the tenets of sustainability and environmental protection.

Method

Data collection for this study utilized survey methods, including participatory observation, interviews, literature studies, and documentation related to agricultural local wisdom in the Urug indigenous community. The interviews were conducted to record opinions, feelings, emotions, and other relevant information related to individuals in the organization. Interviews are conducted to obtain data and understand social and cultural situations through the language and expressions of those being interviewed. Participant observation involves directly observing individual behavior and interactions in the research setting. Therefore, it is essential for researchers to have direct involvement in the daily lives of the subjects being studied. Additionally, document analysis provides unique evidence in case studies that cannot be obtained through interviews and observations alone. This source of data can support the information gathered through observations and interviews. Furthermore, reviewing organizational records can provide data on the historical context of the organizational setting being studied. Sources of data may include administrative records, documentation, and literature reviews.

Figure 1. Research flow

Result and Discussion

The Urug indigenous community performs an annual rice farming procedure, incorporating traditional techniques passed down from generation to generation under the guidance of their customary leader. Figure 1 illustrates the methods utilized by the Urug villagers in their rice cultivation process.

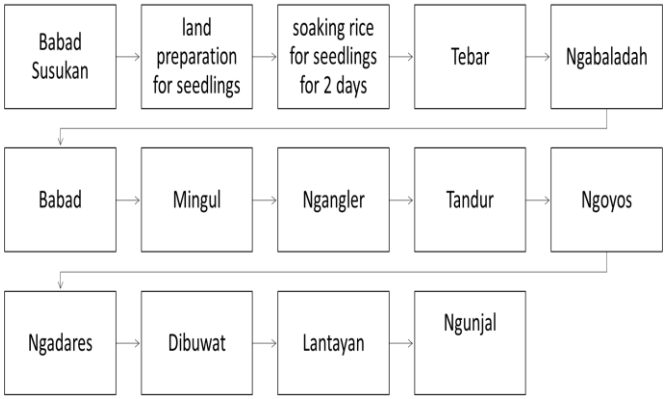

Figure 2. A study of the urug indigenous rice cultivation system

The indigenous community in Kampung Urug utilizes terracing techniques to irrigate their rice fields. This method increases the soil's water storage capacity, resulting in greater water accessibility for crops during periods of limited rainfall (Freitas et al., 2021). Additionally, terracing contributes to enhanced soil quality, carbon sequestration, and land productivity, while also providing erosion control and soil conservation (Wei et al., 2019). River water serves as the primary source of irrigation water. The sediment-laden river water reaches the water reservoir known as susukan. From there, it flows through the ditch and irrigates the rice fields (Bahagia et al., 2020a). Regular cleaning of susukan, through a process called Babad susukan, is necessary for the proper and smooth flow of the water.

The indigenous people of Kampung Urug carry out an annual rice planting process, which entails various advantages. These include improving rice quality, enhancing the ecological environment, contributing to the development of agriculture, farmers, and rural areas, and minimizing planting expenses (Reflis et al., 2011). The traditional leader leads the Urug village's native population in commencing the rice planting process simultaneously. The Kidang constellation's appearance serves as a signal for the Urug community to determine the optimal period for sowing in the fields (Bahagia et al., 2020b). Comprising three stars that travel hand in hand from east to west, the Orion constellation's body frame is formed by four primary stars - Betelgeuse, Bellatrix, Saiph, and Rigel. Orion's Belt is comprised of three main stars - Alnitak, Alnilam, and Mintaka - that form a straight line at the center of this celestial structure.

The appearance of stars in the East is associated with the start of the dry season, while a western position of the constellation Kidang (Orion) signifies the onset of the rainy season. Farmers must be aware of the constellation Kidang or Orion when farming, as the disappearance of Kidang from their line of sight can result in the emergence of pests such as Kungkang or walang sangit. To mitigate this risk, the indigenous people of Kampong Urug plant rice when Kidang appears in the West, with guidance from the Customary Chief. The Urug indigenous people follow the same calendar system as the Javanese agricultural calendar, known as Pranata Mangsa. Pranata Mangsa divides a year into twelve mangsa based on the constellations they correspond with: Mangsa Kasa corresponds with the Cancer constellation, Mangsa Karo corresponds with the Cancer constellation, Mangsa Katelu corresponds with the Crux constellation, Mangsa Kapat corresponds with the Crux constellation, Mangsa Kalima corresponds with the Scorpio constellation, Mangsa Kanem corresponds with the Scorpio constellation, Mangsa Kapitu corresponds with the Capricorn constellation, Mangsa Kawolu corresponds with the Centauri constellation, and etc.

The constellations of Pleyades and Orion are associated with the preys kasonga and kasapuluh respectively, while dhesta is linked to another prey. The constellations related to saddha are the same as those of karo and katelu, and will remain visible based on the prey's age (Badrudin, 2014). Calculations within the mangas system incorporate aspects of phenology and other natural phenomena, providing guidance for farming activities and preparation for potential disasters such as droughts, disease outbreaks, crop disruptions, and floods. Technical terms will be defined upon their initial use, while avoiding bias and ornate language in favor of clear, objective communication. The seasons are closely linked to animal behavior, plant development, and the natural environment, and are tied to agrarian culture.

The tillage process carried out by the indigenous people of Kampong Urug before planting rice has several stages. First, Ngabaladah is the process of hoeing to turn the soil. Second, Babad is the activity of cleaning the grass. Third, Mingul is the process of cleaning the rice field. Finally, Ngangler is the process of leveling the soil with a fork. The tillage process allows air and sunlight to enter the soil, increases soil acidity and moisture, and enhances crop productivity (SK, 2022). Tillage can improve and maintain soil health, which is essential for sustainable agriculture (Cha et al., 2021;

Narender et al., 2023). Rice seeds selected from the previous harvest are soaked for two days and then sown as seedlings. Local rice types are used. This is followed by the stocking process, which involves sowing the rice seedlings. Rice seedlings are typically sown within 40-50 days to increase their resistance against pests, particularly snails.

Seedling maintenance methods, such as seed selection, sowing, and soaking, can enhance seed germination rates and improve seedling disease resistance (Bhanuvally et al., 2017). After Tebar, the next step is Tandur, which involves planting rice using a backward technique with a distance of more than 15 cm between each rice plant to maximize land utilization. This technique makes it easier for farmers to adjust the distance between each rice plant and avoid stepping on the rice during the planting process. Farmers often base their choice of planting orientation and spacing on scientific, economic, practical, and aesthetic considerations. It is recommended to use a seedling size that is appropriate for the planting distance, with a certain conversion rate of seedling yield (kg/plant area) to grain yield per hectare (kg/ha). After Tandur, every month is followed by Ngacak, which is a time to remove weeds that interfere with the growth of rice.

Ngaramed is done every three months to clean the ditches from weeds that also interfere with the growth and development of rice. Weeding is necessary to prevent negative effects on crop production, which can lead to reduced yields and lower crop quality (Doddamani & Revathi, 2022; Sharma & Pant, 2019). Weeds compete with crops for important resources such as nutrients, water, and space, which can hinder crop growth and development. If weed growth is not controlled in time, it can result in significant crop losses, sometimes up to 70% (Sharma & Pant, 2019). The native inhabitants of Kampung Urug perform their rice harvest during the sixth month of the planting season. Using a basic tool known as Etem, they carry out the Mipit procedure that involves marking the rice which is ready for collection. The main rice crops that are gathered for taking to lantayan or pandaringan come only from the Mipit crop.

Once the rice has been gathered, it is stored through the process of Pelantayan, which involves hanging it in a separate room. Unlike the superior variety of Jatuhan rice, the rice cultivated in the Urug region grows local rice. As a result, the customs for managing rice plants are still in place, which includes a distinct drying method. By using Lantayan, the water content drops naturally, eliminating the need to dry it directly in the hot sun. Even during the rainy season, the water content will decrease. After approximately 40 days of the Pelantayan process, rice is stored in a barn called Leuit in an activity known as ngunjal. The harvested rice is stored at Leuit. Developing healthier rice with better dietary fiber composition and reduced glycemic impact can aid diet-based nutrition interventions and decrease the impact of preventable nutrition-related diseases (Butardo & Sreenivasulu, 2016).

The Urug indigenous people's rice planting practices involve scientific elements, including concepts related to astronomy, ecosystems, simple machines, pressure, temperature, and heat. They have developed simple technologies in the form of terracing, etem, and leuit. Agricultural engineering here refers to an approach that works towards a series of ecologically sustainable rice planting processes. Mathematics is a science that deals with numbers, their relationships, and the operational procedures used to solve numerical problems. The calculation processes of the Pranata Mangsa calendar and the Tandur process illustrate this.

The indigenous agricultural system of the Urug tribe incorporates STEM principles into its local wisdom, making it an ideal candidate for integration into the learning process. STEM learning based on local wisdom in addition to increasing students' creativity, critical thinking skills (Mulatsih et al., 2023; Rushiana et al., 2023), science process skills (Mukaromah et al., 2022), High Order Thinking Skill (HOTS) (Ali & Zaini, 2023), students' environmental literacy (Wahyuni et al., 2022) and science literacy (Wahyu et al., 2023). Local wisdom-based learning is easily understandable for students (Yuliana et al., 2023). Formal learning enables students to comprehend the material while also fostering a sense of national pride and other Pancasila values by recognizing themselves and their surroundings. Integrating local wisdom into the learning process has a positive impact on preserving local traditions while also strengthening students' character (Mashami et al., 2023).

Conclusion

According to the research findings, the rice planting processes of the Urug Village indigenous community involve babad susukan, seed preparation, soaking for 2 days, stocking, ngabaladah, babad, mingul, ngangler, tandur, ngoyos, ngadares, dibuwat (harvest), lantayan, and ngunjal. The Urug indigenous community follows a series of rice planting procedures. These include babad susukan, seed preparation, seed soaking for two days, stocking, ngabaladah, babad, mingul, ngangler, tandur, ngoyos, ngadares, dibuwat (harvest), lantayan, and ngunjal. The study of science in the community centers around concepts such as astronomy, ecosystems, simple aircraft, pressure, temperature, and heat. Additionally, simple technologies such as terracing, etem, and leuit are employed. Agricultural engineering focuses on environmentally friendly rice farming. Mathematics

deals with numbers and operations used in solving numeric problems, as in the calculation of the Pranatamangsa calendar and the Tandur. The processes included in this series comprise STEM (Science, Technology, Engineering, and Mathematics) components that provide valuable insights for establishing a sustainable agricultural system. This agricultural knowledge can be integrated into STEM education.

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Author Contributions
SSL contributed to the conceptualization of the research idea, product development, data analysis, and article writing. AR, IK, SS contributed to revising and editing.

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Conflicts of Interest
The authors have disclosed that there are no conflicts of interest in relation to the publication of this paper.

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