REVALUATION OF LOCAL KNOWLEDGE AS A SUSTAINABLE DROUGHT ADAPTATION STRATEGY

Muhamad Khoiru Zaki¹, Keigo Noda², Kengo Ito³ and Komariah⁴

ABSTRACT

Local knowledge can be defined as a person’s ability to use his/her understanding and senses to respond to an event, object, or situation in the local environment. The aim of this study was to reevaluate Pranata Mangsa as a form of local knowledge that can aid in adapting to drought. Pranata Mangsa is used on the Indonesian islands of Java and Bali, particularly by farmers, for managing agricultural activities in the fields and is based on Titen, or natural signs. The relationships between natural signs and farming activities are arranged in four primary and twelve secondary Mangsa, or seasons. Each Mangsa is characterized by activities such as Bero (maintaining fallow land) and burning rice straw, which reduce the loss of crops from meteorological drought and soil moisture deficits caused by agricultural drought. These practices suggest the potential for applying local knowledge to drought adaptation and indicate that a revaluation of the local knowledge of Pranata Mangsa with its specific characteristics could offer an effective strategy for adapting to drought and meeting the 2030 Sustainable Development Goals.

Keywords: Local knowledge, Drought, Soil moisture, Rain-fed farmland

1. INTRODUCTION

In the context of the rapidly expanding agribusiness sector as well as global climate change, the design and implementation of adaptation strategies to drought are crucial to support sustainable agricultural practices. One of the principal strategies of sustainable agriculture in drought-prone areas is to focus on practices requiring minimal tillage, especially those associated with the traditions and experience of farmers in a specific farming area, i.e., local knowledge.

Local knowledge encompasses the experiences of people when interacting with nature and the local surroundings; it originates from their observation of religious customs, following the advice of ancestors, and participating in local culture, and it develops naturally within a community to improve the group’s adaptation to the local surroundings. General behavior and common applications are transmitted and developed by the community, becoming values that are firmly held to create culture and human effort based on people’s utilizing their cognitive power to act toward an object or circumstance in a certain space (Vitasurya 2016).

On the Indonesian island of Java, an important philosophy informed by the local knowledge of the Mataram Empire (1588–1681) is “Hamemayu Hayuning Bawana” which serves as a foundation for community life in the city of Yogyakarta. The literal meaning of this philosophy is “creating a beautiful world.” This can also be interpreted

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¹ The United Graduate School of Agricultural Sciences, Gifu University. Yanagido 1-1, Gifu, Japan. 501-1193. E-mail: zakimuhamad30@gmail.com
² Faculty of Applied Biological Sciences, Gifu University. Yanagido 1-1, Gifu, Japan. 501-1193. E-mail: anod@gifu-u.ac.jp
³ Faculty of Applied Biological Sciences, Gifu University. Yanagido 1-1, Gifu, Japan. 501-1193. E-mail: joroken@gifu-u.ac.jp
⁴ Faculty of Agriculture, Sebelas Maret University. Jl. Ir. Sutami 36A, Surakarta, Indonesia. 57261. E-mail: komariah23@gmail.com
as environmentally friendly development that prioritizes the conservation of natural and cultural assets. This is the key for guiding sustainable local development that does not have detrimental effects on the natural and cultural environments.

Therefore, “Hamemayu” can also be seen as a form of protection from harm to nature and the local society. It contains an inherent understanding that threats to the safety and preservation of the world exist, as well as stating people’s commitment to preserve and protect it (Wagiran 2012).

Hence, the objective of this paper was to reevaluate the local knowledge associated with agricultural practices on the Indonesian islands of Java and Bali, as expressed by the Indigenous populations through their cultures, beliefs, and traditions. We focused on the local crop calendar used in Java and Bali known as Pranata Mangsa.

2. INDIGENOUS PEOPLES OF INDONESIA

Indonesia comprises more than 17,504 islands and covers a total area of 1,904,569 km². It is the fourteenth largest country in the world by land area, and the seventh largest in terms of combined sea and land area. It is the world's fourth largest archipelago and has abundant natural resources, a rich history, diverse cultures, and 1,158 ethnolinguistic groups with different dialects (BPS 2019). The total population is almost 250 million, and the major ethnic groups are the Acehnese, Batakese, Minangnese, Melayunese, Dayaknese, Sundanese, Javanese, Balinese, Bugisnese, and Papuanese.

The Indigenous peoples of the Indonesian archipelago have been able to preserve the cultures and traditions of their "ethnos" or "tribes," including their community views on agriculture, reflected in their farming activities, cropping patterns, and crop calendars. They have long used calendars as markers of the time for agricultural activities, such as for noting the timing of seedlings’ growth, planting, fallow periods, harvesting, and agriculture ceremonies. Generally, the calendar system is based on one or a combination of two astronomical cycles, namely on the cycle of lunar phases (lunar system) or that of the sun’s orbit (solar system). Additionally, various natural signs are used as seasonal markers.

3. PRANATA MANGSA SYSTEM

3.1 History

In Javanese culture, there is a form of local knowledge known as Pranata Mangsa, which was introduced following the provisions issued by Sri Susuhunan Paku Buwono VII in Surakarta on June 22, 1855. Pranata Mangsa is an annual crop calendar for farmers based on the solar cycle; Pranata and Mangsa mean rule and season or time, respectively (Wisnubroto 1999).

3.2 Pranata Mangsa Calendar Adjusted to The Gregorian Calendar

Pranata Mangsa guides the activities of farmers following the cycle of the seasons from year to year and has 366 days in wasu and 365 days in wuntu (Rimanang 2016). The calendar starts on June 22, around the time of the Northern Hemisphere’s summer solstice. This date was chosen as the first day of the Pranata Mangsa because it coincides with the first day of the sun’s return from its northernmost point. The calendar is divided into four primary Mangsa: Mangsa Ketiga (88 days), Mangsa Labuh (95 days), Mangsa rendheng (94 days), and Mangsa mareng (88 days). The primary Mangsa are in turn divided into secondary Mangsa: kasa (22 June–2 August: 41 days), karo (2–25 August: 23 days), and katelu (25 August–18 September: 24 days) in
Mangsa Ketiga; kapat (18 September–13 October: 25 days), kalima (13 October–9 November: 27 days), and kanem (9 November–22 December: 43 days) in Mangsa Labuh; kapitu (22 December–3 February: 43 days), kawolu (3 February–1 March: 26 days), and kasanga (1 March–26 March: 25 days) in Mangsa rendheng; and kadhasa (26 March–19 April: 24 days), dhesta (19 April–12 May: 23 days), and sadha (12 May–22 June: 41 days) in Mangsa Mareng (Figure 1 and Table 1).

Figure 1. Pranata Mangsa as Javanese, Sundanese, Balinese, calendar for managing agricultural activities was adjusted to Gregorian calendar time.

Table 2. The time of Pranata Mangsa crop calendar adjusted to Gregorian calendar.

<table>
<thead>
<tr>
<th>Primary Mangsa</th>
<th>Mangsa Terang</th>
<th>Mangsa Labuh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregorian Time</td>
<td>June - September</td>
<td>September - December</td>
</tr>
<tr>
<td>Secondary Mangsa</td>
<td>Kasa</td>
<td>Karo</td>
</tr>
<tr>
<td>Gregorian Time</td>
<td>22 June - 01 August</td>
<td>02 - 24 August</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Mangsa</th>
<th>Mangsa Rendheng</th>
<th>Mangsa Labuh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gregorian Time</td>
<td>December - March</td>
<td>March - June</td>
</tr>
<tr>
<td>Secondary Mangsa</td>
<td>Kapitu</td>
<td>Kawolu</td>
</tr>
<tr>
<td>Gregorian Time</td>
<td>22 December - 02 February</td>
<td>03 - 28 February</td>
</tr>
</tbody>
</table>
3.3 Natural Signs as Seasonal Markers

The Pranata Mangsa calendar has indicators for determining the beginning and end of Mangsa, or months (Djaldjoeni 1983). In this system, Pranata Mangsa cannot be separated from natural phenomena (Table 2.). For example, when the leaves of the Gadung or Asiatic bitter yam (Dioscorea hispida Dennst.) have opened, they show that the rainy season is imminent.

Table 2. Description of the Pranata Mangsa crop calendar for each Mangsa, showing time, natural signs, and farming activities.

<table>
<thead>
<tr>
<th>No</th>
<th>Mangsa</th>
<th>Mangsa Primer</th>
<th>Time</th>
<th>Natural signs</th>
<th>Farmer activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kasa</td>
<td>Ketiga – Terang (peak dry season)</td>
<td>22 June – 1 Aug. (41 days)</td>
<td>leaves fall down; grasshopper goes into the ground; high temperature</td>
<td>Bero or fallow land; Time to burn rice straw</td>
</tr>
<tr>
<td>2</td>
<td>Karo</td>
<td>Ketiga – Paceklik (dry season)</td>
<td>2 – 24 August (23 days)</td>
<td>Kapok tree (Ceiba pentandra) has flowering</td>
<td>Bero or fallow land:</td>
</tr>
<tr>
<td>3</td>
<td>Katelu</td>
<td>Ketiga – Semplah (last dry season)</td>
<td>25 Aug. – 18 Sept. (24 days)</td>
<td>Bamboo sprouts were growing</td>
<td>Palawija or secondary crop cultivating</td>
</tr>
<tr>
<td>4</td>
<td>Kapat</td>
<td>Labuh – Semplah (early rainy season)</td>
<td>19 Sept. – 13 Oct. (25 days)</td>
<td>Kapok was fruit development, Birds egging or hatchlings</td>
<td>Palawija harvesting</td>
</tr>
<tr>
<td>5</td>
<td>Kalima</td>
<td>Labuh – Semplah (rainy season)</td>
<td>14 Oct. – 9 Nov. (27 days)</td>
<td>First precipitation was come down to the earth</td>
<td>Paddy seedling on the tray</td>
</tr>
<tr>
<td>6</td>
<td>Kanem</td>
<td>Labuh – Udan (rainy season)</td>
<td>10 Nov. – 22 Dec. (43 days)</td>
<td>Fruit trees become mature with a small fruit</td>
<td>Land preparation on Paddy field</td>
</tr>
<tr>
<td>7</td>
<td>Kapitu</td>
<td>Rendheng – Udan (peak rainy season)</td>
<td>23 Dec. – 3 Feb. (43 days)</td>
<td>High precipitation, and flooding in a river</td>
<td>Paddy transplanting to the field</td>
</tr>
<tr>
<td>8</td>
<td>Kawolu</td>
<td>Rendheng - Pangarep- arep (rainy season)</td>
<td>4 – 2/29 February (26/27 days)</td>
<td>Cats reproduction time</td>
<td>Fertigation on paddy vegetative phase</td>
</tr>
<tr>
<td>9</td>
<td>Kasanga</td>
<td>Rendheng - Pangarep- arep (last rainy season)</td>
<td>1 – 25 March (25 days)</td>
<td>Cicididae has sounded in nature</td>
<td>Paddy on reproductive phase</td>
</tr>
<tr>
<td>10</td>
<td>Kadhasa</td>
<td>Marèng - Pangarep-arep (last rainy season and no precipitation)</td>
<td>26 Mar. – 18 Apr. (24 days)</td>
<td>Walang sangit or rice ear bug (Leptocorisa oratorius Fabricius) attack to paddy field</td>
<td>Paddy on ripening phase</td>
</tr>
<tr>
<td>11</td>
<td>Dhesta</td>
<td>Marèng – Panèn (early dry season)</td>
<td>19 Apr. – 11 May (23 days)</td>
<td>Kapok fruit has mature</td>
<td>Paddy harvesting</td>
</tr>
<tr>
<td>12</td>
<td>Sadha</td>
<td>Marèng – Terang (dry season)</td>
<td>12 May – 21 June (41 days)</td>
<td>Temperature become high</td>
<td>Harvest ceremony</td>
</tr>
</tbody>
</table>

Pranata Mangsa is also associated with the behavior of certain animals as indicators of the start of a Mangsa. The appearance of a walang sangit, or rice ear bug (Leptocorisa oratorius Fabricius.), for example, is regarded as a sign of the beginning of the Mangsa Ketiga, which is the dry season. In Mangsa Ketiga, the natural signs are Terang, or high temperatures and no rain, and grasshoppers burrowing into the ground; and this season is a time of Paceklik, or food scarcity. According to Pranata Mangsa, the agricultural activities that must be carried out by farmers during this time are burning rice straw, maintaining Bero or fallow land, or preparing the land for planting with...
Palawija or secondary crops, such as corn, peanuts, and soybeans, that do not need much water.

Mangsa Labuh is the transitional season between the end of the dry season and the beginning of the rainy season, or Mangsa semplah in the Javanese language. The natural sign associated with this season is the flowering of the kapok (Ceiba pentandra) tree (Figure 2a.), which indicates the beginning of a small amount of rainfall. In Mangsa Labuh, farmers harvest Palawija or secondary crops. In addition, farmers start to plant rice seed in trays and prepare the paddy fields for planting by arranging irrigation channels or gullies in the fields.

Mangsa rendheng, also called Mangsa udan, is the period of high rainfall, and it ends with the very loud calls of garengpung, or cicadas (Figure 2b). In Mangsa rendheng, irrigation water is not needed; therefore, this period is suitable for transplanting rice from the trays to the paddy fields. During this season, drainage conditions must be tended because there are frequent floods.

![Figure 2. Natural signs of Pranata Mangsa a) Kapok trees (Ceiba pentandra) as a natural sign for the end of dry season and beginning rainy season; b) garengpung or Cicadidae as a natural sign for the end of rainy season and ends the rainy season.](image)

Figure 3. Refugia plants on side of paddy field as an effort of IPM for repelling pests. Mangsa Mareng marks the end of the rainy season and the beginning of the dry season. The natural sign for this Mangsa is the arrival of Walang sangit, or rice ear bugs, in the paddy fields. At this time, the rice is ripe and ready to be harvested; therefore, farmers perform a type of integrated pest management using “refugia” plants (Figure 3).
4. THE PRANATA MANGSA FARMING SYSTEM AND DROUGHT ADAPTATION STRATEGY

4.1 The Pranata Mangsa Farming System

A farming system is a resource management strategy that aims to achieve sustained agricultural production to meet diverse requirements of a farming-based livelihood, ideally while preserving the resource base and maintaining a high level of environmental quality (Lal and Miller 1990). In addition, farming systems represent the appropriate combination of farm enterprises (cropping systems, horticulture, livestock, fishery, forestry, poultry) and the means available to the farmer to manage them for profitability. Ideally, farming systems interact effectively with the environment without disrupting the ecological and socioeconomic balance, while attempting to meet the national agricultural goals (Chang et al. 2016).

Pranata Mangsa is also associated with a farming system and guides farmer activities in the field, including crop type and patterns. The calendar is divided into two types of climate conditions: the dry season, from 22 June to 22 December, and the rainy season, from 22 December to 22 June (Figure 4).

The Pranata Mangsa farming system incorporates both primary and secondary crops. Paddy rice, which is cultivated as the primary crop, is planted in Mangsa kalima (14 October–9 November) and harvested in Mangsa dhesta (19 April–11 May). The growing period is very long, up to 6 months for one crop, and there is only one harvest during the whole year. It is due to Pranata Mangsa that local varieties of rice, called Kopo, Ketan hideung, and Marahmay, are still used, which grow to heights of 145–177 cm (Rohaeni & Hastini 2015). Maize, soybean, and peanut are cultivated as the secondary crops, or Palawija, using mixed cropping to mitigate the risk of drought damage. The growing period for the secondary crops cuts across Mangsa, from the end of the dry season to the earlier rainy season (25 August–13 October; 49 days).

A single year’s crop rotation in Pranata Mangsa (starting from 22 June) can be described as follows:

Bero – Palawija - Paddy
Bero means fallow; in this Mangsa, no crops are cultivated in the field (Noordwijk 1999). Ryan et al. (2008) reported that the fallow system of wheat cultivation in Syria increased organic matter in the soil. Increasing soil organic matter plays a pivotal role in rain-fed areas because of its disproportionate influence on soil moisture, nutrient availability, and yield stability (Mikha et al. 2006; Rasmussen & Collins 1991). Using a fallow system can increase the storage of water in the soil profile and mitigate the effects of widely varying precipitation amounts in rainfed areas (Nielsen et al. 2010). William et al. (2008) reported that crop residue in fields, such as that from maize and wheat, decreased run-off and evaporation, and increased infiltration.

Bero is used in Pranata Mangsa during the period from Mangsa kasa to Karo (22 May–24 August; 64 days). Pranata Mangsa dictates that the farmer burn the rice straw after harvesting and then leave the land fallow. This is based on Titen, or nature signs that are observed by old people and have been linked to precipitation conditions for 30 years (1985–2014) in Mangsa Kasa and Karo, when the precipitation was lower than that in other Mangsa and less than 50 mm (Zaki et al. 2018a).

4.2 Pranata Mangsa for adapting to drought

Drought adaptation strategies are embedded in the farming system of Pranata Mangsa. For example, burning rice straw can increase soil moisture (Padbhushan et al. 2016), which is key for managing agricultural drought (Zaki et al. 2018b). In addition, Pranata Mangsa might offer an effective strategy for adapting to meteorological drought, for example, to Bero, which takes place during Mangsa kasa and Karo (22 June–24 August; 64 days), a period characterized by lower precipitation (<50 mm in total). Pranata Mangsa suggests that the farmer follow Bero, leaving the field fallow, to reduce the risk of yield loss due to water deficit.

5. CONCLUSIONS

Drought has impacts on many aspects of society, including agriculture, the economy, and health. One impact that commonly occurs in the agricultural sector in Indonesia is crop failure. Effective adaptation strategies to drought can be derived from a revaluation of Pranata Mangsa. Pranata Mangsa is a form of local knowledge used in Indonesia to guide farming activities. It is based on Titen, i.e., observations of the dry and rainy season, natural signs, and local resources (organic amendments and local crop varieties), and it is suitable for adapting to different types of drought (meteorological, agricultural, hydrological, and socio-economic) using sustainable practices.

However, the application of strategies such as those derived from Pranata Mangsa is not straightforward. Future challenges include difficulty in predicting weather anomalies and changes in and the appearance of new natural signs, such as animal extinctions. Furthermore, Pranata Mangsa is unfamiliar to younger generations, and there are increasingly fewer people with this knowledge. Revaluation and a better understanding of Pranata Mangsa is important for researchers and government authorities, who can advocate its benefits to the general population, especially to farmers, to promote effective drought adaptation strategies.

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7. REFERENCES


