Assessment of use of meteorological information among farmers: A case study in Indonesia

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Abstract

Using so-called KATAM, a crop calendar being promoted by the Indonesian government for agricultural risk management, as a case study, the present paper aims to identify factors that affect the extent of use among farmers of meteorological information. To this end, it employed structured interviews with farmers (n = 422) in three different regencies in Java. It also conducted follow-up surveys in two villages during the recent drought to understand how meteorological information was used at the farmer level. This study finds that the importance of meteorological information, as viewed by farmers relative to other factors that also influence farming decisions, differs by location. It is therefore important to understand the contexts of agricultural decision-making in order to exploit the potential benefits of meteorological information. While this study finds a decreasing significance of local knowledge of weather forecasts, it points to the importance of the role of extension workers to help farmers in understanding the implications of meteorological information on their agricultural production and livelihoods. This study also finds that education is the most significant factor for differentiating the use of KATAM, which indicates that the tool may have uneven effects, potentially exacerbating existing inequalities.

Key words: Crop calendar, Indonesia, Meteorological information, Risk management.

1. Introduction

The present study aims to identify factors that affect the extent of use among farmers of meteorological information, particularly the ‘Integrated Crop Calendar System (Sistem Informasi Kalendar Tanam Terpadu, KATAM)’, one of the risk management tools being promoted by the Indonesian government to secure food production in the face of climate variability and change. KATAM was first introduced by the Ministry of Agriculture in 2007, and upgraded in 2010, becoming more frequently updated with seasonal forecasts provided by the Agency for Meteorology, Climatology and Geophysics (Badan Meteorologi, Klimatologi, dan Geofisika, BMKG). KATAM has been equipped with more content, such as recommendations on varieties of paddies as well as the types and amounts of fertilizer to be used. Furthermore, an online system was launched and a mobile platform using the short message service (SMS) has also become available for accessing KATAM.

Using KATAM as a case study, the present paper aims to assess the use of meteorological information among farmers. There is a range of relevant prior and ongoing studies. Vogel and O’Brien (2006), for example, argued that climate information is seen as a promising but underused tool for agricultural risk management, largely because of the lack of understanding about the individual contexts in which agricultural decisions are made. Climate is only one factor that influences production decisions; other factors, such as the ability to gain access to resources like land, labor, fertilizer and credit, are likely to confound a farmer’s response to variations in climate. Therefore, the use of forecasts among farmers can be constrained by the limited production alternatives. The authors contend that responding to varying climate is not assured by climate information dissemination alone, and call for finding ways of matching climate information to farmers’ concerns, needs, and priorities. Similarly, Ingram et al. (2002) noted that farmers need greater access to basic agricultural technologies, such as plows, new crop varieties, and fertilizers, before they can benefit fully from forecasts. Ziervogel and Cartwright (2010), on the other hand, argued that communication between climate information providers and users should be strengthened, and indicated that one of the key ways to achieve this is to support ‘translators’ who understand the challenges of both groups and who can facilitate a meaningful dialogue between them. One of the ongoing initiatives in Indonesia and other Asian countries is a prototype weather rice-nutrient integrated decision support system (WeRise), a web application tool to provide farmers with weather and crop advisories, which has been produced and tested under the collaboration of Japan and the International Rice Research Institute (IRRI). WeRise is designed for extension workers and farmers who can access the Internet (Boling et al., 2014).

2. Method

The present study employed structured interviews conducted in June 2015 with rice farmers in six villages in each of three regencies (Kabupaten): Cirebon, West Java; Demak, Central Java; and Pasuruan, East Java (Fig. 1), which are among the most substantial paddy production areas in Indonesia. While Demak is mostly rain-fed, Cirebon and Pasuruan are mostly well irrigated (Suk-
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The Indonesian government provided farmers in these regencies with training concerning farming practices and tools, including KATAM, for supporting adaptation to climate variability and change. The training was conducted from 2014 to early 2015 and attended by 422 farmers, all of whom were interviewed for this study. The questions, as listed in Appendix, were discussed with government staff and extension workers in advance, and pre-tested with several farmers.

The interview results were used to understand the significance of differences in distribution in terms of the respective attributes, as indicated in Table 1, between farmers who either had already used or intended to use KATAM, called Group 1 \((n_1 = 223)\), and those who neither had used nor intended to use it, including those who had no understanding of it, called Group 2 \((n_2 = 199)\). To this end, Microsoft Excel was used to conduct an independent sample t-test or chi-square testing at \(p < .05\), depending on whether ordinal or categorical variables were in question. With regard to the attributes for which the difference between the two groups was found to be significant, hypothesis testing was also conducted to determine whether there were any significant differences in distribution.

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Table 1. Profile of the farmers interviewed \((n = 422): the numbers of applicable farmers are shown in the parentheses: 1 USD = approx. 14,000 Indonesian rupiah)\).

<table>
<thead>
<tr>
<th>Location</th>
<th>Cirebon (131), Demak (147), Pasuruan (144)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male (376), Female (46)</td>
</tr>
<tr>
<td>Age</td>
<td>Less than 40 (144), 40–49 (140), 50–59 (120), 60 or older (48)</td>
</tr>
<tr>
<td>Highest education</td>
<td>Not complete primary school (73), Primary school (156), Junior high school (77), Senior high school or higher (116)</td>
</tr>
<tr>
<td>Seasonal household revenue</td>
<td>Less than 2 million rupiah (54), 2–4 million rupiah (179), 4–6 million rupiah (80), 6–8 million rupiah (40), 8 million rupiah or higher (69)</td>
</tr>
<tr>
<td>Family size</td>
<td>3 or less (118), 4–5 (255), 5 or more (49)</td>
</tr>
<tr>
<td>Size of cropland</td>
<td>Less than 0.5 ha (139), 0.5–1.0 ha (166), More than 1.0 ha (117)</td>
</tr>
<tr>
<td>Status of cropland</td>
<td>Own (248), Rent (152), Profit-sharing (50)</td>
</tr>
<tr>
<td>Crops to be planted (*)</td>
<td>Paddy (418), Maize (136), Soybean (16), Peanut (15)</td>
</tr>
<tr>
<td>Main crop</td>
<td>Paddy (416), Maize (6)</td>
</tr>
<tr>
<td>Cropping pattern</td>
<td>Paddy-paddy-no plant (145), Paddy-paddy-maize (104), Paddy-paddy-paddy (95), Paddy-maize-no plant (11)</td>
</tr>
<tr>
<td>Most important farming activity</td>
<td>Paddy preparation plowing (202), Seeding (15), Transplanting (46), Fertilization (91), Pesticide application (21), Harvesting (8), Others (39)</td>
</tr>
<tr>
<td>How the timing of the mentioned farming activity is decided</td>
<td>Individually (350), Collectively (72)</td>
</tr>
<tr>
<td>Most important factor for the mentioned farming activity</td>
<td>Rainfall (151), Irrigation water (49), Availability of fertilizer (46), Availability of seeds (27), River water (24), Others (125)</td>
</tr>
<tr>
<td>Main source of information for the mentioned factor</td>
<td>Observation of natural phenomena (192), Extension workers (63), BMKG weather forecast (34), Farmer group (32), Traders of fertilizer (30), Staff of irrigation service (12), Others (59)</td>
</tr>
<tr>
<td>Whether a change in climate conditions is being perceived</td>
<td>Yes (386), No (36)</td>
</tr>
<tr>
<td>Confidence in local knowledge for weather forecast</td>
<td>Very confident (44), Confident (242), Others (136)</td>
</tr>
<tr>
<td>Importance of externally-produced weather forecast</td>
<td>Very important (81), Important (244), Others (97)</td>
</tr>
<tr>
<td>Whether a mobile phone is owned</td>
<td>Yes (326), No (96)</td>
</tr>
</tbody>
</table>

Note (*) Multiple answers allowed.
bution of farmers by location \( n_{\text{Cirebon}} = 131, n_{\text{Demak}} = 147, n_{\text{Pasuruan}} = 144 \), which was intended to ascertain whether there were any site-specific effects. Other findings were based on qualitative data.

In order to understand the contexts in which agricultural decisions are made and how meteorological information is used, the current study also included follow-up surveys by visiting the village (Desa) of Bumirejo in the district (Kecamatan) of Karangawen and the village of Gebangarum in the district of Bonang, both located in the regency of Demak, in early October 2015, when they were in the middle of what was deemed the most acute drought since 1997. Demak was chosen since, out of the three previously-mentioned regencies, it was found to be the place where externally-produced weather information, such as BMKG weather forecasts, was most frequently used, making it suitable for follow-up to learn how meteorological information was used to support farming decisions. The head of farmer group leaders, some other individual farmers, and an extension worker were interviewed in the respective villages to ask the following questions: (1) How were the situations of drought and harvest loss in the latest dry season? (2) How are farming activities (paddy preparation plowing, seeding, transplanting, fertilization, pesticide application, and harvesting) normally scheduled and how were they this season? (3) At which stage of the farming process were the drought impacts recognized and how? (4) Was any drought warning provided? If so, when and how was it delivered? (5) What kinds of preventive and/or coping measures were taken? When and how were they taken? (6) How was the weather forecasted for this season? When and how was it delivered? (7) How was meteorological information applied in the decision-making? and (8) Was KATAM accessed and applied? If so, when, how, and by whom?

3. Results

3.1 Results of interviews

The present study found that the differences in the frequency distributions for farmers between Groups 1 and 2 were significant at \( p < 0.05 \) in terms of location. Farmers in Cirebon were significantly less likely to use KATAM, and those in Demak were more likely to use it, while those in Pasuruan were evenly distributed between the two groups. This study also revealed that the distributions for farmers were significantly different at \( p < 0.05 \), not only between the two groups but also between the three regencies in terms of (1) what farmers consider the most important farming activity; (2) the factor that most strongly affects that farming activity; and (3) the main source of information to indicate the factor. The comparison between the three regencies is illustrated in Fig. 2 to 4.

The vast majority (87.8%) of farmers in Demak consider paddy preparation plowing to be the most important farming activity (Fig. 2), and more than two thirds (67.3%) regard rainfall as the most influential factor (Fig. 3). While nearly half (49.7%) observe natural phenomena to seek indications for rainfall, many farmers (21.1%) also rely on weather forecasts provided by BMKG (Fig. 4). By comparison, the importance of paddy prepa-
and transplanting factor that substantially affects the mentioned farming activity is casts as the main source. The current study also found that the vast of fertilizer (25.0%) longer changes in climate conditions, such as dry seasons becoming (25.0%) Pasuruan is fertilization (25.0%) followed by plowing (20.8%) and transplanting (12.5%), as shown in Fig. 2. As shown in Fig. 3, participants offered a variety of responses concerning the effect factors, which include rainfall (17.6%), water flow in river channels (16.0%), and availability of seeds (9.9%) and fertilizer (7.6%). While observation of natural phenomena is dominant (71.8%), advice from extension workers is frequently mentioned as the main source of information (22.1%), with the BMKG forecast being cited by only a few (2.3%), as shown in Fig. 4. In contrast, the farming activity most widely mentioned in Pasuruan is fertilization (43.8%), followed by plowing (18.8%) and transplanting (12.5%), as shown in Fig. 2. Accordingly, the factor that substantially affects the mentioned farming activity is the availability of fertilizer (25.0%), followed by rainfall (20.1%), water level in irrigation channels (12.5%), and the availability of seeds (9.0%), as shown in Fig. 3. Various sources of information for such factors are also mentioned, such as traders of fertilizer (20.1%), observation of natural phenomena (17.4%), farmer group (16.7%), extension workers (13.9%), and staff of the irrigation service (6.9%), as shown in Fig. 4.

None of the farmers interviewed in Pasuruan cite BMKG forecasts as the main source. The current study also found that the vast majority (91.5%) of farmers in the three regencies perceive changes in climate conditions, such as dry seasons becoming longer (40.8%) and hotter (13.7%). A large number (67.8%) of farmers replied that they are either very confident or confident about local knowledge of weather forecasts, which are based on a variety of observable indicators. The start of the rainy season, for example, is believed to be indicated by shrill-toned sounds of beetles (13.0%), a flock of storks flying around villages (12.1%), local trees going into blossom (9.8%), and the strong chirping of crickets (8.3%). On the other hand, the majority (77.0%) of the respondents also consider externally-produced weather forecasts to be very important or important, even if they are not the main source of information for many of them.

While mobile phones are a key means for accessing KATAM, this study revealed that the distribution of mobile phone ownership among farmers does not significantly differ between Demak and Pasuruan, although a significant difference concerning the use of KATAM was found to exist between the two regencies. This indicates that owning mobile phones alone does not significantly affect the use of KATAM. Among those who have tried KATAM, the majority (60.9%) accessed it by SMS, while others relied on the Internet (24.2%) or extension workers (10.9%). This increased dependence on SMS rather than the Internet is related to the finding that only half (50.6%) of the mobile phones owned by the respondents were equipped with a function to access the Internet. Among those farmers who do not own smartphones, only less than a third (29.1%) have alternative means of accessing the Internet. Farmers accessed KATAM for several purposes, such as obtaining information about the timing of transplanting (49.5%) and rainfall forecasts (32.0%). About a third of the users with valid responses considered the information about the timing of transplanting (35.5%) and rainfall forecasts (31.2%) to be useful. Among those farmers who regard the forecast information as useful, the majority (86.8%) were based in Demak.

The present study also revealed that the distribution of farmers significantly differed between the two groups in terms of highest education. As shown in Fig. 5, farmers with limited education, such as those who did not finish primary school, were significantly less likely to use KATAM. On the other hand, other attributes such as age, household revenue, and size of cropland were not identified as significant factors.

### 3.2 Results of the follow-up survey

Located in the highlands, the village of Bumirejo has more than 300 ha of paddy area being cultivated by five farmer groups. Researchers visited one of these groups, called the Bumirejo Makmur, cultivating about 160 ha of paddy fields with around 80 member farmers. As shown in Fig. 6, they have three planting seasons in a normal year: the first for paddy production during the wet season from October to February; the second also for paddy, from February to June when the rainfall amount decreases month after month; and the third for maize (60%), tobacco (30%), and vegetables (10%) during the dry season from July to October. The normal paddy harvest is 10-11 ton/ha in the first season and 7-8 ton/ha in the second.
At the time of the interview, the farmers had not experienced rainfall for almost five months since May. This is a longer and more severe dry season than found in the recent record in the district, as illustrated in Fig. 7. (The figure was created using the rainfall data, as monitored by BMKG in Jragung, another village in the district of Karangawen, from 1995 to 2014. A number of data are missing. Only available data were used to calculate the average, maximum, and minimum rainfall by month. This is the only monitoring station in the district.) As it is rain-fed, paddy production in the village had been hit hard by the drought, with the harvest yielding only 5-6 ton/ha in the latest second planting season. In the ongoing third season, 80% of the cropland, much more than normal, was being used for production of tobacco, which is more drought resilient but less profitable than maize. While paddy preparation plowing, seeding, transplanting, fertilization, pesticide application, and harvesting are scheduled as shown in Fig. 6 in a normal year, the farmers started the second planting season one week earlier than the regular schedule due to the early warning of drought, which had been communicated through the extension worker. In order to reduce the risk of pest attack, the
farmers normally leave the field fallow for three to four weeks between the first and second planting seasons. In response to the drought warning, however, they shortened the fallow period and starting the second planting season earlier. Around 40 to 45 days after planting, the farmers noted that the growth of grains was worse than had been anticipated. In order to prevent entire crop failure, they followed the advice of the extension worker to conduct the harvest two weeks earlier than normally scheduled. Even though widespread failure was thus avoided, the harvest was still smaller than expected.

The farmer group meets the extension worker every 35 days throughout the year to discuss a range of agricultural problems. The extension worker also provides information regarding the availability of seeds and fertilizer, as well as seasonal weather forecasts. Extension workers, on the other hand, attend a meeting organized by the local government around one month before the start of each planting season in order to obtain information, including weather forecasts, which will then be communicated to the farmers. When urgent matters arise, the extension worker contacts the head of the farmer group. The interviewed farmers noted that, even though some older farmers in the village still use observation of natural phenomena to seek indications for the change of seasons, most farmers rely on information provided by extension workers. They also indicated an interest in KATAM, but expressed their preference to receive the information, particularly concerning rainfall and fertilizer, through the extension worker.

The village of Gebangarum is located in the lowlands near the coast. Researchers visited one of six farmer groups in the village, called the Makmur Barokah, which cultivates a total of 42.8 ha of rain-fed paddy fields with 57 members. As indicated in Fig. 6, they have two planting seasons in a year: normally the first for paddy from September to January, and the second also for paddy, from February to May. The rainfall data shown in Fig. 8 indicates that it is dry from May to September in this district. In a normal year, the paddy harvest is 6-7 ton/ha in the first season and around 4.5 ton/ha in the second. According to the interviewed farmers, a lack of surface water led to seawater intrusion, which resulted in the harvest being only 0.5 ton/ha in the latest second planting season. While the farming activities are normally scheduled in the first planting season as indicated in Fig. 2, the lack of water prolonged the duration of this season by about one month, with the harvesting being completed in February instead of January. Subsequently, this delayed the start of the second planting season, which finished as late as July.

Farmers in the village used to rely on a change in wind direc-
tion as an indication for the arrival of the rainy season. They mentioned, however, that this is becoming less reliable, and that they depend more on externally-produced weather information, which is provided through the extension worker, together with other agricultural information. The farmers also have meetings with officials of the village, which take place before the start of each planting season, to receive a range of information on farming, including weather forecasts.

4. Discussion

The results of the current study underline the importance of understanding the context in which farming decisions are made in order to exploit the potential benefits of meteorological information as a tool for agricultural risk management. The importance of meteorological information, as viewed by farmers relative to other factors that also influence farming decisions, differs by location. This differentiates the likelihood of farmers using KATAM as a source of meteorological information. As the cropland is mostly rain-fed in Demak, information concerning rainfall is viewed by farmers as overwhelmingly important for their farming activities, in particular paddy preparation plowing. In comparison, the relative importance of meteorological information is lower in Cirebon and Pasuruan, where the cropland is generally well irrigated. Even if it were to be seen as important, meteorological information is viewed as only one of many important factors, such as the level of irrigation water and the availability of fertilizer.

While the number of samples is limited, the follow-up surveys in two villages in Demak demonstrate that farmers need someone, like extension workers, to support them in interpreting meteorological information in the context of their decision-making. Extension workers are expected to help farmers understand the implications of meteorological information on their agricultural production and livelihoods. Farmers also prefer to obtain meteorological information through extension workers rather than being direct recipients of the information, because this has been the long-established way of communicating farming information. The importance of such an intermediary role was similarly discussed by Ziervogel and Cartwright (2010). These findings suggest that the government should target extension workers rather than individual farmers if it wants to promote KATAM. It should be recognized that extension workers are assigned two or three villages respectively, and each village has several farmer groups. The climate and socio-economic conditions may also differ between villages. In this regard, the government needs to consider how it can better support extension workers in responding to the distinctive needs and concerns of villages.

While the interviews in the three regencies found education as the significant factor for differentiating the use of KATAM, this indicates the possibility that the tool may have uneven effects, potentially exacerbating existing inequalities. In this regard, the role of extension workers as translators of climate information for those who need it, including the less educated farmers, should also be highlighted.

The results of the follow-up survey in Demak demonstrate the increasing relevance of externally-produced weather information, along with the decreasing significance of local knowledge for weather forecasts. Therefore, great efforts are required to increase the accuracy of KATAM. As the meteorological information of KATAM is provided at the district level rather than the village level, the resolution also needs to be improved. While it is still in the early stage of introduction, the validity of KATAM needs to be tested further.

5. Conclusion

Using KATAM as a case study, the present paper aims to comprehend factors that affect the extent of the use of meteorological information among farmers. To this end, it employed structured
interviews with individual farmers (n = 422) in three different regencies in Java, and included follow-up surveys in two villages during the recent acute drought to understand how meteorological information was used by farmers. The importance of meteorological information, as viewed by farmers relative to other factors that also influence farming decisions, differs by location. It is therefore important to understand the contexts of agricultural decision-making in order to exploit the potential benefits of meteorological information. The current study also identifies the importance of extension workers in helping farmers understand the implications of meteorological information on their agricultural production and livelihoods. On the other hand, the finding that education is the significant factor for differentiating the use of KATAM indicates the possibility that the tool may have uneven effects, potentially exacerbating existing inequalities.

One important limitation of the current study needs to be acknowledged. Three regencies, where the Indonesian government provided farmers with training concerning farming practices and tools, including KATAM, were chosen as the target sites under this study. As they are all located in the northern part of Java, the validity of the findings may need to be tested in other locations with different climate and socio-economic conditions.

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Appendix: List of questions for the structured interviews

Screening questions:
S1. Did you attend the training organized by the Indonesian Ministry of Agriculture?
S2. Are you a farmer?

Questions:
Q1. How old are you?
Q2. What is your highest education?
Q3. What is your seasonal revenue?
Q4. How many family members do you have?
Q5. Do any of your family members have a mobile phone?
Q6. For those who own a mobile phone, is the Internet accessible from it?
Q7. For those without smartphones, are there any alternatives to access the Internet?
Q8. What crops do you plant?
Q9. What is the main crop?
Q10. What is your annual cropping pattern?
Q11. What is the status of your cropland? (Do you own or rent?)
Q12. How many hectares of cropland do you cultivate?
Q13. Which farming activity is the most important for you?
Q14. Is the timing of the mentioned activity decided individually or collectively?
Q15. What is the most important factor that affects the mentioned activity?
Q16. Rank the importance of other factors potentially affecting the mentioned activity.
Q17. What is the main source information for the mentioned factor?
Q18. Do you know of any natural phenomena to be used for forecasting the weather?
Q19. What are such phenomena?
Q20. How confident are you on the mentioned phenomena to be used for forecasting?
Q21. Do you perceive any changes in climate conditions during your lifetime?
Q22. What are your perceived changes?
Q23. Are you aware of KATAM?
Q24. Have you used KATAM?
Q25. For those who have used KATAM, how did you access?
Q26. For those who have used KATAM, what was the purpose?
Q27. For those who have used KATAM, which elements of KATAM were useful?
Q28. For those who never used KATAM, do you intend to use in the future?

(Note) Gender and location are recorded.

References


