ISSN 1819-1894

Asian Journal of Agricultural Research

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS

Asian Journal of Agricultural Research

ISSN 1819-1894
DOI: 10.3923/ajar.2017.66.77

Research Article
Use of Climate Forecast Information to Manage Lowland Rice-Based Cropping Systems in Jakenan, Central Java, Indonesia

[1,2]Elsa Rakhmi Dewi and [1,3]Anthony Michael Whitbread

[1]Tropical Plant Production and Agricultural Systems Modelling (TROPAGS), Georg-August University Goettingen, Grisebachstr. 6, 37077 Goettingen, Germany
[2]Indonesian Agroclimate and Hydrology Research Institute (IAHRI), Bogor, West Java Indonesia
[3]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, 502324 Telangana, India

Abstract
Background and Objective: Smallholder farmers of Jakenan in Central Java must manage several climate-related risks including flood and drought events that occur more frequently, negatively affecting crop production and rural livelihoods. The use of climate forecasts had become important in coping with climate risk. This study assessed how farmers apply climate forecast information to manage rice cropping systems. The objective of this study was to identify factors affecting how farmers are using climate forecast information in rice-based cropping system in Jakenan, Central Java. **Materials and Methods:** The study was based on face-to-face interviews with smallholder farmers, using a semi-structured questionnaire conducted in 4 villages (Ngastorejo, Tlogorejo, Bungasrejo and Sendangsoko) in Jakenan sub-district from December, 2013 to February, 2014. A total of 100 farmers were selected randomly based on a list of farmers available in each village. The response of respondents was then statistically analyzed using the SPSS version 22 and the mean differences were determined by Independent t-test. **Results:** Results showed that in Jakenan, Central Java, farmers were influenced by several factors such as management practices, knowledge of climate forecasts and the process of decision making for farming practices with regard to the use of climate forecast. Based on the survey, most of respondents had knowledge of climate forecasts (72%) and used them for planting time determination (94%) and selection of crop varieties (91%). Adjusting planting time and selecting proper crop varieties has become their main strategy in coping with climate variability. **Conclusion:** Based on these results, the level of farmer knowledge mainly affects the use of climate forecast at the farm level in this region. Better knowledge of climate forecasts enabled farmers to interpret complex situations and adopt innovations hence minimizing climate risk and yield reduction.

Key words: Climate variability, planting time, varieties selection, climate forecast, farmer adoption, innovation

Citation: Elsa Rakhmi Dewi and Anthony Michael Whitbread, 2017. Use of climate forecast information to manage lowland rice-based cropping systems in Jakenan, Central Java, Indonesia. Asian J. Agric. Res., 11: 66-77.

Corresponding Author: Elsa Rakhmi Dewi, Indonesian Agroclimate and Hydrology Research Institute, Jl. Tentara Pelajar No. 1A, 16111 Bogor, Jawa Barat, Indonesia Tel: +62-81210319461

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesia is a country greatly affected by climate variability being an archipelago country located in the equatorial region and influenced by variability in sea-surface temperatures (SST)[1]. This geographical position means that Indonesia is a meeting point of the meridional circulation (Hadley) and the zonal circulation (Walker), both of which have a strong influence on climate variability[2]. In addition, the position of the sun throughout the year and monsoonal activity also play a role in climate variability.

The productivity of lowland rice-based cropping systems, being the main farming system in Indonesia, is closely linked to climatic variables such as rainfall and temperature. These systems are highly vulnerable to changes in rainfall pattern, due to the fact that the crops are seasonal and sensitive to water stress. The rainfall has great influence in determining rice growth and production because of its high variability both in time and place[2].

One of the factors that strongly influence rainfall variability is the phase of the El-Nino Southern Oscillation (ENSO) phenomenon, which is more likely to occur along with an increase in climate variability. The ENSO phenomenon will disrupt the circulation of Walker, a circulation that is caused by the power of pressure gradient between a high-pressure system over the eastern Pacific Ocean and a low-pressure system over Indonesia. When the Walker circulation becomes weak, the surface of ocean is warmer than average and sometimes resulting in an El-Nino event. Whereas, a strong Walker circulation causes ocean temperature to be cooler than the average due to increased upwelling and related to the high incidence of La Nina events. Consequently, a drastic decline in rainfall amount sometimes associated with El Nino events or excessive rainfall sometimes associated with La Nina may lead to prolonged drought or water logging, respectively[2]. The influence of ENSO on rainfall events has been especially significant for the dry season[3]. Changes in rainfall patterns and intensity due to ENSO might cause an increase in drought events in rice-cultivated areas and therefore, a decline in rice production. In Java, the El Nino events of 1991, 1994 and 1997 decreased the cultivated rice areas by more than 50% and delayed planting time to the next season[3]. Based on an analysis of dry season rainfall data for the past 100 years, a decrease in rainfall below normal due to El Nino may reach 80 mm per month, while an increase of rainfall above normal due to La Nina may be less than 40 mm per month. This indicates that the occurrence of El Nino events pose a more serious threat than La Nina events[1].

Smallholder farmers are among the most vulnerable groups to be most affected by climate change[4]. The IPCC[5] indicates that the activity and productivity of smallholder farmers can be influenced by yield reduction as crop damage and crop failure and/or the increase of rainfall and flooding that result in water logging of soils. Studies show that smallholder farming in many regions is influenced by climate variability and dealt with the risk induced by climate change[6-8]. In line with that, climate change models mostly predict that small farmers will be affected by climate impacts, especially in rainfed farming systems in developing countries[9].

Like most Indonesian provinces on Java Island, Central Java predominantly implements a rice-based cropping system. In these cropping systems, farmers generally plant two or more rice crops a year. The first rice crops are planted during the wet season, while the second and third rice crops are planted during the dry season. In addition, many farmers include dry season crops such as maize and legumes as the third crops. The impact of climate change is being experienced by smallholder farmers in this area and will continue to pose a threat in the future as climate variability increases. An increase in droughts, heavy rainfall and flooding events will cause not only crop damage through crop failure, but also reduce crop yield and threaten food security[10].

As smallholder farmers rely on the rice-based cropping system for their livelihoods, they need to enhance their management of current climate variability through climate services information to cope better with climate risk and to adapt to future climate change[11]. The knowledge and skills of farmers regarding climate phenomena and rainfall will assist them in optimizing the use of rainfall in each season, so that they can increase crop production and prepare for extreme events over the season. In addition to that, the right time of crops planting can be determined by the onset forecast that will help the farmers to prevent false starts. This information can also be used to define strategies to prevent drought risk during dry cropping season[12]. Climate forecast information therefore has to be reliable to be used effectively by the farmers.

Climate information is regularly disseminated by the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) to Indonesian governmental departments, businesses and citizens[13]. This information is based on the Standardized Precipitation Index (SPI) method, which has been provided by Australia, using Seasonal Climate Outlooks for Pacific Island Countries (SCOPIC) software. SPI is an index that is computed based on the probability of the recorded rainfall amount throughout every region in Indonesia (i.e., positive index values for wet and negative for drought conditions). It can also be used to observe climate conditions at various intervals such as monthly, quarterly, seasonal and annual[14].

For agricultural purposes, climate information is coordinated and served by the Ministry of Agriculture, the National Center for Agricultural Extension Development. At an operational level, district agricultural extension workers and the Regional Disaster Management Agency (BPBD) deliver climate information to the farmers.

There are several regular outputs of such climate services, such as helping farmers plan their crop management with crop calendars and variety selections.These products include the forecast of rainy and dry season onset, forecast of monthly rainfall (up to 3 months lead time), return period map of maximum rainfall, climatology of rainfall, temperature and wind. In addition, climatology of rainy and dry season onset, maps of shifts of rainy and dry season onset, vulnerability maps to drought for rice producing provinces and Climate Field School (CFS) for farmers in crop producing provinces are also included[15].

Since rice crops are generally planted in an annual cycle, the risk factors for a second rice crop are bigger. Drought is then a dominant factor in decision-making, as it is one of the main factors that lead to crop failures. Widespread drought areas are strongly linked to the ENSO phenomenon and changes in sea surface temperature (SST). During El Nino years, dry season rainfall will decrease and irrigation water will be very limited, thus it cannot irrigate all the fields. Subsequently, the onset of rainy season is often delayed, by as much as 3 months. Planting of the first crop will therefore be delayed and this eventually also delays the second crop[3].

El Nino years may bring not only decreased rice production, but also outbreaks of some important pests and rice diseases, such as stem borer, brown planthopper and tungro disease. As reported by Indonesian national newspapers (Kompas) on February 26th, 2003, there has been an increase in the intensity of brown planthopper and rat infestation by 500 and 1695 ha, respectively in January, 2003 and to 800 and 2000 ha in the following month[3]. If the extreme events can be predicted earlier, such attacks can be avoided and hence, minimizing yield reduction. However, results of surveys in several districts in Java indicate that the ability to anticipate extreme climate events is low, as to the ability to accurately forecast weather is not good and the adoption level of climate forecast by the farmers is quite low. To intensify the effective use of climate forecast information, the knowledge of farmers and their ability to understand and predict the response of agricultural systems to climate variability should be improved. Consequently, better-tailored management decisions in response to favorable or adverse conditions may be implemented and thus crop losses and variability can be reduced.

This study therefore aimed to (i) Specify factors affecting how farmers are using climate forecast information in lowland rice-based cropping system in Jakenan, Central Java, (ii) Identify farmers' perceptions of current climate variability and change and (iii) Enhance awareness and adoption of farmers to climate forecast information.

MATERIALS AND METHODS

Site description: The survey was conducted in Jakenan sub-district, in Pati district, Central Java, Indonesia. Jakenan is situated 16 km East of Pati. The area covers around 5300 ha and is at an altitude of 10-25 m above sea level. The entire area is located in the lowlands with undulating landscapes and the dominant soil type being Tropaqualf. Most people here rely on rice cropping for their livelihoods and hence the study region therefore represents particularly lowland rice-based cropping systems. These systems are mainly characterized as rainfed lowland rice with a dry-seeded crop planted from November-February during the rainy season, followed by transplanted rice from March-June during the dry season[16]. These predominantly irrigated crops may be followed by an intensified rainfed fallow phase in the form of soybean or mung bean grown from July-October in the dry season. The rainy season in Jakenan generally starts in November and ends in April or May, while the dry season starts in May or June and ends in October. Average annual rainfall is 1596 mm. Average minimum temperature is 23.6°C and average maximum temperature 31.2°C. During the last decades, undesirable conditions such as delayed onset, erratic rainfall and flooding have occurred, disturbing crop production.

Data collection and analysis: The study was based on face to face interviews with smallholder farmers, using a semi-structured questionnaire of open and closed questions. The interview was conducted in 4 villages in Jakenan sub-district from December, 2013-February, 2014. Currently, this study can provide information on how farmers use climate forecast information to manage rice cropping system. The level of knowledge, skills and motivation of farmers to apply climate forecast information in undertaking rice farming activities can therefore be improved. The selection of villages was based on discussion with agriculture and livestock staff of Pati district. The selected villages (Ngastorejo, Tlogorejo, Bungasrejo and Sendangsoko) are considered to be vulnerable to climate risks such as droughts, floods and erratic rainfall and representative of rice based farming systems in the region. A total of 100 farmers in

Jakenan sub-district were selected randomly based on the list of farmers available in each village. Thus each village was represented by 25 respondents.

Respondents were asked about their basic background such as age, education level, family and land size. Farmers' perceptions of climate change and its impacts, commonly practiced in the field and the ability and habit on climate forecast associated with farming practices were also asked to them. The response of respondents was subsequently compiled and analyzed using the SPSS version 22 statistical analysis package.

Farmers' perceptions of current climate variability and change were compared with the climate data recorded by Indonesian Agricultural Environmental Research Institute (IAERI). Daily data of temperature and rainfall was analyzed to specify variability and trends for the period 1983-2013 (30 years) for the selected weather station in the study area (Jakenan sub-district). Jakenan weather station is located at 6°75' latitude and 111°17' longitude in Pati district. However, since IAERI began to record climate data in 1990, daily data of temperature and rainfall missing prior to that year was downloaded from the National Aeronautics and Space Administration (NASA) prediction of worldwide energy resource. Data from the period of 1983-1989 (7 years) was then downloaded to fill in the missing ones. The mean and standard deviation of monthly, seasonal and annual rainfall were calculated with box and whisker plots used to show the distribution of rainfall. Standardized anomalies for rainfall with respect to the long-term average values were used to evaluate inter-annual variability. Linear regression was conducted to determine temperature and rainfall trends.

The availability of climate information is usually disseminated by BMKG. Near term climate information covers monthly forecasts of total rainfall and total rainfall relevant to normal. In addition, a 3 month forecast is released and updated monthly. Meanwhile, medium term climate information covers the onset of wet or dry seasons and total rainfall relevant to normal during the season. The dry season forecast is released at the beginning of March and that of the rainy season forecast at the beginning of September[17].

The vulnerability of lowland rice-based cropping systems to climate variability can be identified by using rice production data over time. A line can be fitted to rice production data as the trend line. Thereafter, anomalies from the line fitting data were regarded as responses of the lowland rice-based cropping system to climate variability. Rice production data of the Pati district was downloaded from the Indonesia Ministry of Agriculture and used in this study for the period 1986-2013, as long-term data for the Jakenan sub-district level was not available.

RESULTS AND DISCUSSION

Characteristics of the respondents: The characteristics of respondents are presented in Table 1 with the age of respondents (around 80%) between 31 and 60 years. Respondents within this age range were considered to be actively engaged in farming activities and therefore, potentially capable to understand and adopt climate forecast information.

In terms of education level (Table 2), many of the respondents (60%) had attended junior or senior high school and 30% of respondents had elementary school education or none. The level of education is important, as it is said to affect the capability of people to adopt innovation processes. Since the majority of respondents experienced relatively high levels of education, a better adoption of climate forecast information can be expected. In addition, farmers who had highest education level may influence those who had a low education level by introducing and encouraging the role of climate forecast information.

Family and farm size also corresponded to the characteristics of respondents (Table 3). The size of family generally related to income with the higher the number of family members, the more income required to meet the needs of the household. Farmer's income particularly derives from their farm productivity. Other family members can contribute

Table 1: Distribution of respondents (n = 100) based on age at Jakenan, Central Java, Indonesia

Age range (years)	Respondents (%)
20-30	6
31-40	27
41-50	33
51-60	24
>61	10

Table 2: Distribution of respondents based on education levels at Jakenan, Central Java, Indonesia

Education levels	Respondents (%)
No education	1
Elementary School	32
Junior High School	22
Senior High School	39
Collage/Academy	6

Table 3: Distribution of respondents based on family and farm size at Jakenan, Central Java, Indonesia

Family size	Respondents (%)	Farm size (ha)	Respondents (%)
0-3	14	<1	29
4-6	80	1-2	49
>6	6	>2	22

to their income by farming or non-farming practices. The size of farm usually determines farmers' income with larger farm sizes resulting in higher income levels.

Around 80% of respondents had 2-4 children, while others (14%) had one or no children and 6% had more than 4 children. For the farm size, 50% of the respondents had 1-2 ha, around 30% had less than 1 ha and 20% had more than two ha. The result of family size is in accordance with the farm size of respondents. A Pearson product-moment correlation coefficient was used to assess the relationship between the household number and farm size. There was a positive correlation between the two variables ($p = 0.007$), an increase in family size was correlated with an increase in farm size.

Farmer perceptions of climate variability and change: Based on farmer perceptions, 85% of respondents believed rainfall had decreased whilst 77% considered that temperature had risen and high temperature events have become more common over the last 20 years (Fig. 1). Moreover, 80% of interviewed farmers stated that rainfall has become more erratic and all mentioned that the drought and flood events have increased. Twenty years ago the frequency of drought and flood events occurred once in every 8-10 years, but now drought was said to occur every 2-3 years, while floods occur almost every year. In their opinion, the increase of flood events is due to high intensity of rainfall during the rainy season, the silting of the river of Juwana and deforestation. Farmers have therefore faced reductions in crop production and crop failure due to such undesirable events.

Comparison of climate analysis with farmers' perceptions on climate variability and change

Rainfall pattern and variability: The rainfall pattern over the period 1983-2013 in the Jakenan sub-district was monsoonal, characterized by unimodal rainfall distribution. The maximum monthly rainfall occurs in December, January and February, while the minimum monthly rainfall occurs during June-September (Fig. 2). This circumstance corresponds with the appearance of the monsoon in Indonesia. The West monsoon season usually starts from December-February. On the other hand, the East monsoon season starts from June-August. Figure 3 shows a separate box and whisker plot of rainfall over the period 1983-2013. The skew of rainfall distribution of annual and rainy season seems to fall into lower part, meaning that rainfall variability was low, while the skew of rainfall distribution of dry season seems to fall into upper part, indicating that rainfall variability was high.

The distribution of seasonal rainfall is an important factor to be considered, as crop production and selection in Jakenan continually takes place in rainy season. During this period, 55% of the years between 1983 and 2013 indicated negative rainfall anomalies relative to the long-term mean. On the other hand, the dry season indicated negative rainfall anomalies for 48% of the years (Fig. 4a-c). In general, annual and seasonal rainfall in Jakenan showed a slight decrease over the period 1983-2013. The trend was statistically significant ($p<0.05$) for annual and the rainy season rainfall, but there was no statistically significant trend for the dry season rainfall. Rainfall anomalies in rainy season also corresponded with ENSO events for the year 1987, 1991, 1994, 1997, 2002, 2004 and 2010.

Temperature changes: Figure 5a-b shows the changes of temperature over the periods of 1983-2011 at the Jakenan weather station. The last 2 years of data, 2012 and 2013 have been removed from the analysis due to extreme temperatures. Temperature trends show that the minimum and maximum temperatures for Jakenan station have not increased for the last 20 years.

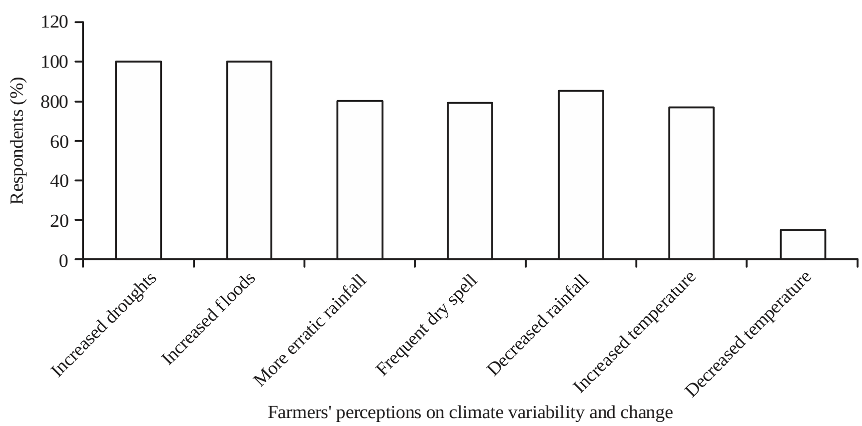

Fig. 1: Farmers' perceptions on climate variability and change
Based on interviews with 100 farmers in Jakenan, Central Java, Indonesia

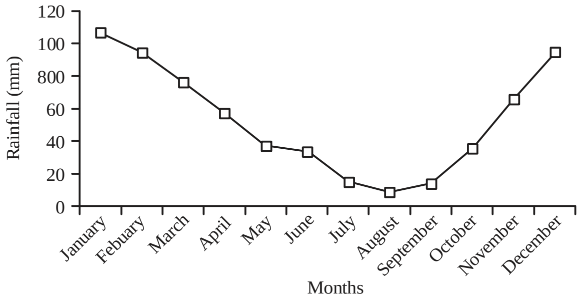

Fig. 2: Mean monthly rainfall over the period 1983-2013 at Jakenan weather station, Central Java, Indonesia

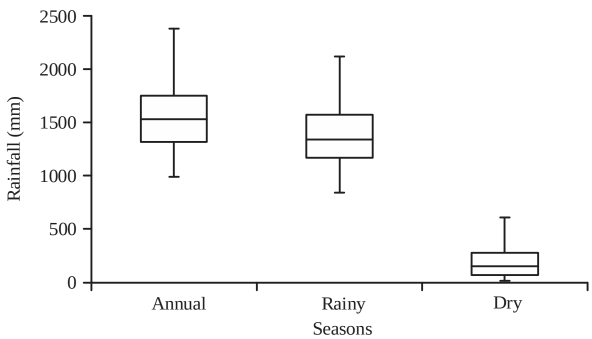

Fig. 3: Box and whisker plot of annual and seasonal rainfall (mm) over the period 1983-2013 at the Jakenan weather station, Central Java, Indonesia

Lower and upper boundaries for each box are the 25th and 75th percentiles. The line inside each box indicates the median, The Whiskers mark represents the ranges for the bottom 25% and the top 25% of the data values, excluding outliers, Standard bar represents standard error of the mean

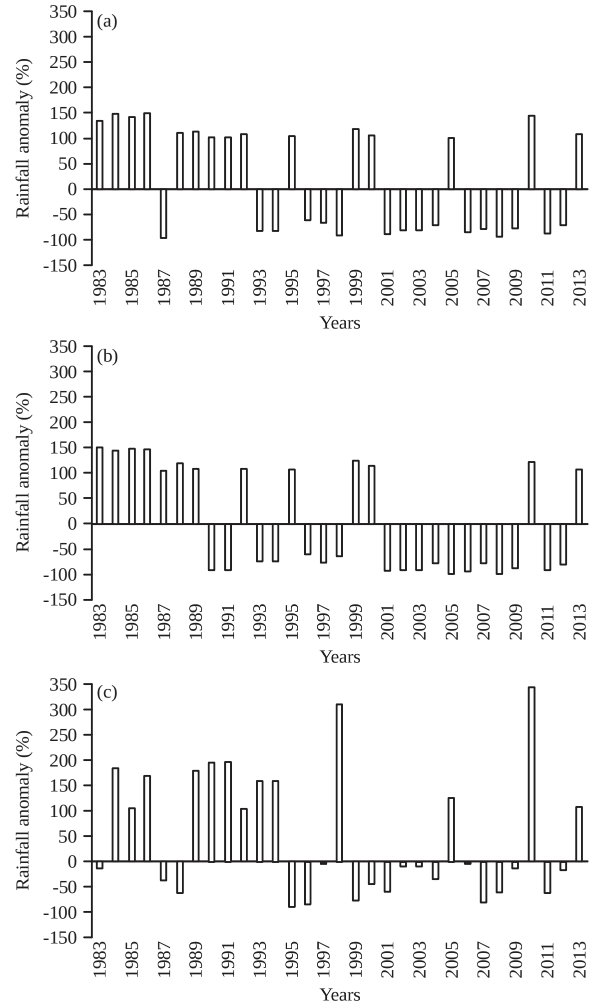

Fig. 4(a-c): (a) Annual, (b) Rainy and (c) Dry season rainfall deviations from the long-term means over the period 1983-2013 taken from the Jakenan weather station, Central Java, Indonesia

Response of lowland rice-based cropping system to climate variability: Rice production trends are generally influenced by factors such as technology interventions, size of planting area and climate variability. To identify responses of lowland rice-based cropping systems to climate variability, factors other than climate variables therefore should be removed. The variables data was fitted to the line of the rice production data. Rice production over the period 1986-2013 in the Pati district fluctuated and continued to increase after 2007 (Fig. 6a).

Deviations from the line fitting (anomalies data) can then be regarded as a response of lowland rice-based cropping systems to climate variability (Fig. 6b). Figure 6b shows that the negative anomalies of rice production mainly occurred in El Nino years.

Crop management practices: In Jakenan, the lowland rice cropping system was commonly characterized by two times of rice planting during the rainy season, followed by legumes during the dry season under rainfed conditions. Almost 80% of the interviewed respondents in Jakenan indicated rice-rice-mungbean as their main cropping pattern (Table 4). As the crop is grown under rainfed conditions, management practices particularly rely on water availability either from irrigation or rainfall. Considering this, it was asked by farmers about the factors in determining cropping patterns.

The numbers of respondents in Jakenan who consider water availability in determining their cropping pattern are 64%, while other respondents consider tradition (28%) and crop maintenance (8%) as the reason for the selection (Fig. 7). This number refers that most farmers notice on water irrigation and rainfall, thus in determining their cropping pattern the rainy season is usually taken into account. In addition, many farmers include the yield price in determining cropping pattern, indicating that they are affected by the market.

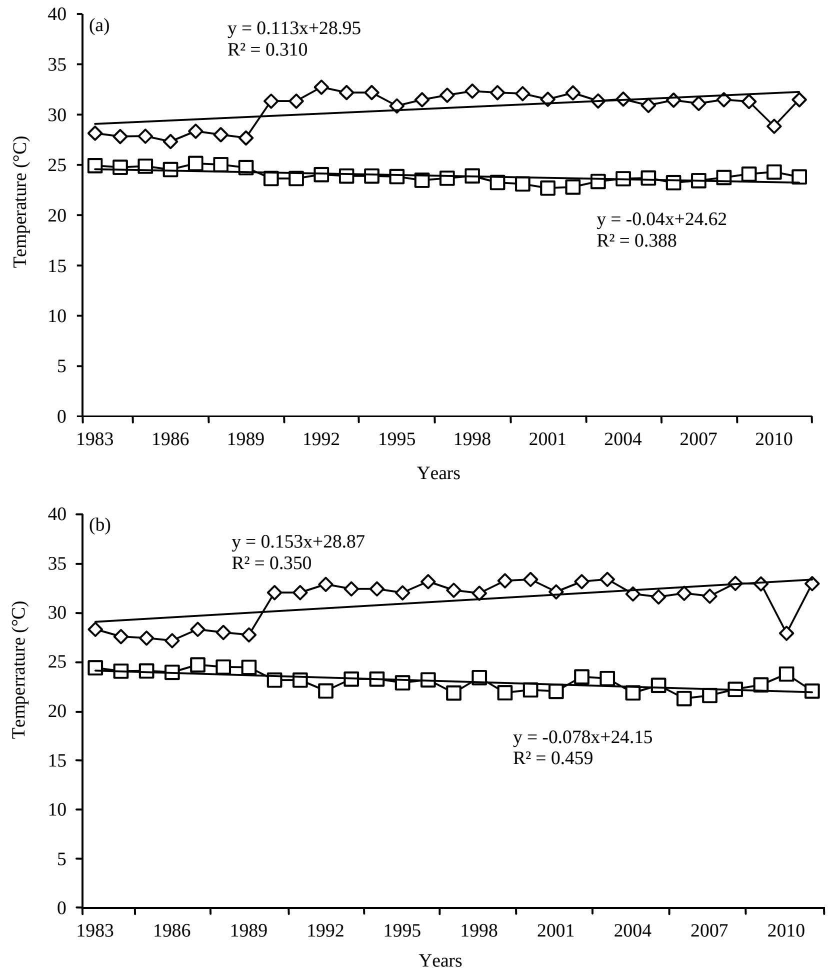

Fig. 5(a-b): Trend of minimum and maximum temperatures of (a) Rainy and (b) Dry season over the period 1983-2011 at the Jakenan weather station, Central Java, Indonesia

Table 4: Selection of cropping pattern based on farm survey in Jakenan, Central Java

Cropping pattern	Respondents (%)
Rice-rice-rice	2
Rice-rice-fallow	5
Rice-rice-mungbean	78
Rice-rice-soybean	11
Rice-rice-maize	1
Rice-maize-fallow	3

To meet crop water requirements, farmers commonly apply irrigation by pumping water from the river of Juwana, which passes through the Jakenan sub-district. Around 68% of the respondents stated that supplemental irrigation were applied over rice growing season, while other respondents did not apply such management practices (32%). Depending on the size and location of the farm, farmers require high or low cost for pumping water. The bigger the farm size and/or the further the farm is from the river will determine how high such costs will be. Interestingly, farmers do not apply irrigation to legumes over the growing season to save costs. Therefore, they will select a crop that requires less water during the dry season as the water availability relies on the rainfall.

Effects of climate variability and change: Effects of climate variability and change on crop production and management as perceived by farmers are presented in Table 5. All respondents indicated that climate effects have reduced crop yield and household income. Around 96% of respondents encountered partial or total crop failure and 82% experienced an increase in pest and disease infestation. The increase in pest and disease infestation was felt within respondents as the frequency of drought and floods events increased. For instance, the increase in abundance of brown planthopper and rats typically occurred after floods. In addition, ca. 85% of respondents have changed the cropping pattern and 91%

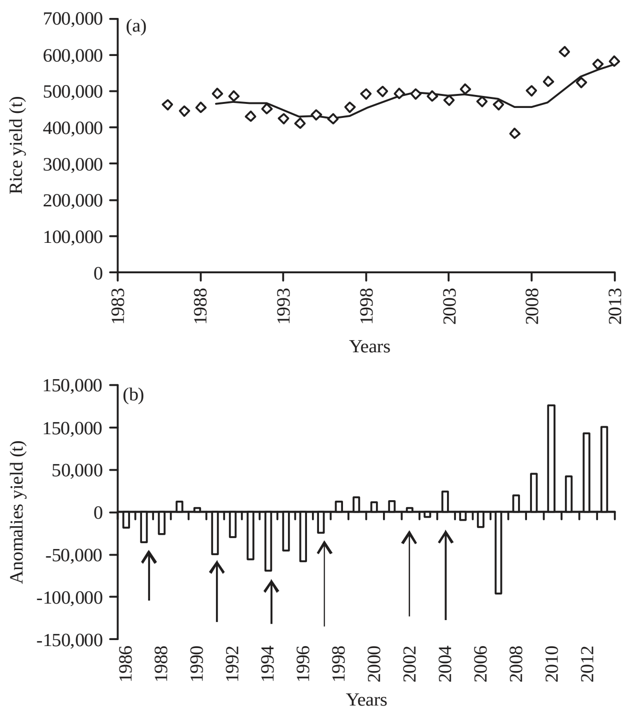

Fig. 6(a-b): (a) Trend and (b) Anomaly of rice production over the period 1986-2013 in the Pati district, Central Java, Indonesia

The arrows indicate El Nino events

have changed the crop varieties, which were mostly tailored to water availability. Because of the high climate variability and extreme events experienced in the area, farmers were convinced that the incidence of food shortages has increased in their region over the recent history.

Knowledge on climate forecast: As climate forecast information plays a role in improving management practices in farming systems, particularly dealing with climate variability and change, it is therefore asked by farmers about their knowledge of climate information. According to the survey about 70% of respondents have knowledge of climate forecast, while about 30% of them do not (Table 6). It was further asked by farmers who have knowledge of climate forecasts about how they get the information. Data from the survey showed that farmers use several sources (Table 7). About 86% of respondents indicated that the information comes from agricultural agencies, who regularly visit them, while 32% of respondents mentioned that the forecast information is associated with traditional knowledge and 25% get this from television. Based on farmers' opinion, traditional knowledge is typically related to the condition of fauna or flora, or the position of stars or the moon. However, such knowledge is sometimes not applicable, as the farming systems have changed along with the fauna and flora previously used as indicators.

Table 5: Effects of climate variability and change on crop production and management as perceived by smallholder farmers in Jakenan, Central Java

Effects	Respondents (%)
Major change in cropping pattern	85
Partial or total crop failure	96
Reduced crop yield	100
Change in crop varieties	91
Increase pest and disease infestation	82
Loss income	100
Food shortage	59
Decline consumption	15

Table 6: Farmers' knowledge of climate forecast based on survey in Jakenan, Central Java

Description	Respondents (%)
Do not have knowledge	28
Have knowledge	72

Table 7: Farmers' sources of climate forecast based on survey in Jakenan, Central Java

Source of climate forecast	Respondents (%)
Newspaper	21
Television	25
Traditional knowledge	32
Agriculture agencies	86
Neighbor	18

Table 8: Role of climate forecast on farming activity based on survey in Jakenan, Central Java

Farming activity	Respondents (%)
Crop varieties selection	91
Planting time adjustment	94
Changing cropping pattern	73
Crop risk management	15

The use of climate forecast in decision making: Most of the respondents do not have the ability to predict the response of lowland rice-based cropping systems to climate variability and to manage the risk that may arise from it. Respondents were then given a follow-up question related to the role of climate forecast information in decision making for farming practices. Around 94% of respondents selected changing the planting time as their main response when using climate forecast information (Table 8). Farmers usually begin planting when the rains start and replaces freshwater in the river (diluting any salt content). Hence, farmers are able to use water to irrigate the crops. Looking at current climatic variability, farmers felt that climate forecast information is not useful for determining planting time. They have to adjust the time of the onset of rain. Planting can therefore can be delayed as the onset of

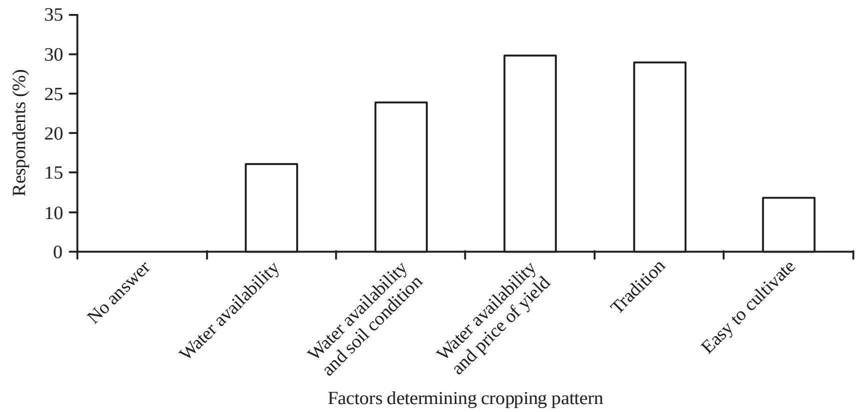

Fig. 7: Factors in determining cropping pattern
Based on interviews with 100 farmers in Jakenan, Central Java, Indonesia

rainy season is late. On the other side, planting can begin earlier when the onset of the rainy season is early, but farmers must wait for rain to occur for at least 3 days in a row. Early planting can also prevent crops from flood risks although farmers may get low yield as the crop is harvested earlier.

Around 91% of farmers stated that climate forecast information is used to select crop varieties. The selection of crop varieties is adjusted to match seasonal condition (i.e., drought resistant). Another activity is changing cropping patterns. Seventy three percent of farmers interviewed chose changing cropping patterns in the use of climate forecast information. Farmers adjust the cropping pattern from season to season. They can grow rice during the rainy season and when the dry season starts they can select crops that require less water.

Farmers' perceptions on climate variability and change: Climate data observed at the Jakenan weather station indicates that there is high annual and seasonal rainfall variability (Fig. 4a-c), which is in accordance with the perception of farmers (Fig. 1). Rainfall variability shows that the months of July-September experienced lower rainfall, which may lead to dry spells, while the months of December-February had higher rainfall, which often induces flooding (Fig. 2). Furthermore, monthly rainfall patterns have been become erratic from year to year (data not shown here). Other studies in East Java also showed increasing rainfall trends during the wet season, but decreasing rainfall trends during the dry season, resulting in dry spell periods[18]. The temperature trend, however, is not in line with farmers' perceptions of increasing temperature over the last 20 years (Fig. 1, 5a-b). The distinction of farmers' perceptions for temperature trends and recorded data might be due to an increase in pest and disease prevalence, causing yield reduction. The analysis therefore can provide a basis for farmers to arrange soil preparation and planting time according to the period of reliable and even rainfall distribution. Meanwhile, to deal with dry spell periods during the growing season, farmers are encouraged to adopt water harvesting techniques to irrigate the crops. Rainfall variability can hence influence not only farming systems, but also cropping strategies. As stated by Ravindran[19], crop management strategies and planning should take the statistical analysis of historical rainfall into account especially if seasonal forecasts are not available.

Rice production in the Pati district is closely related to El Nino years, as negative anomalies of rice production mainly occur in these years (Fig. 6b). El Nino has several impacts on rice production. Firstly, it influences the onset of the rainy season so that the first rice cropping during rainy season is delayed. As a result, the second rice crop is also delayed, hence an increase in drought risk as rainfall at the end of plant growth is reduced. Secondly, El Nino causes dry season rainfall below normal, meaning the water availability is not enough to support plant growth. Thirdly, El Nino leads to the onset of dry season starts earlier than usual, resulting in the second rice crop experiencing drought stress[2]. If climate forecast information is known beforehand, measures to avoid such circumstances can be carried out immediately. For instance, when climate forecast shows that the onset of the rainy season is delayed for 1-2 months, the second rice cropping is not recommended, especially if dry season rainfall is normal or below normal.

Farmers' perceptions on climate variability and change are based on their memories over the last 20 years (Fig. 1). This can cause a problem as farmers may use such information in dealing with constraints which effects are unclear or unpredictable[20]. A decline in rainfall perceived by farmers may be related to an increase in temperature. High temperature can influence not only soil moisture, texture and structure but also soil capacity to retain water. When the soil dries without the addition of water either from rainfall or irrigation, crop begin to wilt, causing plant death. The changes in temperature and soil conditions that affect crop water availability, can further affect farmers' perceptions of decreasing rainfall. In addition, frequency of droughts and floods has increased over the last 10 years based on their opinion. Farmers stated that the increase of drought events were due to dry season rainfall having decreased to the extent that there is not enough water to irrigate crops. As a result, rice production has declined and farmers are occasionally not able to grow crops during the dry season, therefore reducing household income. Comparing farmers' perceptions on rice production with the analysis of trends and anomalies of rice production in the Pati district (Fig. 6a-b), a reduction of rice production can be related to the El Nino events as dry season rainfall was below normal.

According to farmer opinion, the main factors that cause the occurrence of floods are a high intensity of rainfall during the rainy season and the silting of the river of Juwana. Deforestation of the Muria forest also contributes flood events in this region. Agriculture agencies mentioned that local government has planned a project to normalize the river however, it has not been approved by central government because it requires substantial funds. If there is no attempt to normalize the river, floods will continue to occur annually. Muria forest areas should be improved by replanting but it will take several years for trees to absorb the amount of water necessary for them to provide the desired service. Other effects of climate variability and change are yield reduction, crop failure and pest and disease infestation, which are also observed by farmers. All of these have affected farmers' income and food security, as households have less income and can therefore buy less food. However, this analysis requires a more detailed study that covers cultural conditions, socio-economic and local environmental issues so that comprehensive information can be gathered. Unfortunately, this was beyond the scope of this study.

Factors affecting farmers in using climate forecast in lowland rice-based cropping system: Crop management practices such as cultivation and irrigation management are the first factors adjusted in response to climate forecasts in lowland rice-based cropping system. These management practices usually will consider cropping patterns that are selected by farmers in order to improve crop production. Most of the respondents (80%) select rice-rice-mungbean as their main cropping pattern since they have to adjust to water availability (Table 4, Fig. 7). To reach optimum growth, crops require large quantities of water. Crop growth is therefore influenced by the amount and timing of water applied over the production period. Water status also affects crop vigor and its resistance to insects and diseases infestation. Water should be managed properly so that optimum growth can be achieved and crop production improved. This finding is in line with the study conducted in Lombok Island, Indonesia, which showed that farmers in dry land areas considered water availability as the main factors in deciding cropping patterns[21].

Since water management is important for the success of crop growth, farmers rely on irrigation availability and rainfall to irrigate crops. Sixty eight percent of interviewed farmers applied supplemental irrigation to meet crop water requirements. Irrigation is particularly applied to water-based rice crop, while dry season crops (i.e., mungbean, soybean) depend on rainfall or residual soil water. A number of farmers (32%) did not apply supplemental irrigation and simply relied on rainfall to irrigate their crops. Water management is then based on cost of supplemental irrigation, where farmers must consider whether the costs of such inputs are comparable to the yield obtained. Pumping water from the river to the field is costly, farmers have to set the installation up and buy fuel to operate the pump. To minimize the costs, farmers will select crops that require less water during the dry season so they do not have to apply irrigation. A solution that has been implemented among local farmers has been the formation of farmer groups who co-operate to share the costs around the installation of supplemental irrigation. This issue needs serious attention from farmer communities and government to help deal with water availability.

Knowledge on climate forecast is another aspect that affects the use of climate forecast (Table 6). Based on the farm survey, farmers of a productive age and a better education level were able to receive and adopt climate forecast information (Table 1, 2). The productive age of a farmer coupled with a comparatively better education leads to a better interpretation of complex situations and adoption of innovation processes[22]. Knowledge on climate forecast allows farmers to transfer technology related to climate forecast information. Agricultural agencies, therefore play an important role in delivering climate forecast information to the farmers. Group discussions are held regularly in order to improve their knowledge and skill related to climate forecast information. Also, being a part of group enables the farmer to easily access climate forecast information, helping in decision making for farming practices.

The last aspect that influences farmers in using climate forecast is the process of decision making for farming practices. To this day, farmers use the information to adjust planting time and to select appropriate crop varieties in order to cope with climate variability (Table 8). Survey studies have shown that adjusting planting time is an effective strategy to cope with climate variability[23,24]. Farmers have to adjust planting time to the onset of rainy season. Planting can therefore either be delayed if rainy season starts late, or earlier it starts early. However, the ability to use climate forecast information to manage climate risk was limited (i.e., coping with El Nino years). In other words, climate forecast information has not been used effectively by farmers, as their adoption level of it was low. Governments should therefore give more attention to this, so that farmer knowledge and skill in relation to climate forecasts can be improved and crop yield losses minimized.

CONCLUSION

There are several factors that affect farmers in using climate forecast information namely management practices, knowledge on climate forecast and the process of decision making for farming practices. Farmers' knowledge of climate forecasts determined further crop management practices in coping with climate variability. Planting time adjustment and the selection of appropriate crop varieties were the main management practices selected by the farmers in dealing with climate risk and yield losses. Farmer adoption levels however were low considering climate risk management, especially in coping with El Nino events. To interpret complex situations and to adopt innovation, better knowledge on climate forecast is therefore required by the farmers so that climate risk and yield reduction can be minimized.

SIGNIFICANCE STATEMENTS

This study indicates that most farmers in Jakenan, Central Java use climate forecast for planting time and cropping pattern decisions to manage climate variability. Understanding the socio-economic status of smallholder farmers and the communities they live in, will provide important information for policy makers and extension services for preparing effective crop management strategies. This study also enriches literature on the application of seasonal climate forecasts and allows general insights on the adaptive strategies farmers, use to cope with climate variability.

ACKNOWLEDGMENTS

The authors thankfully acknowledge the director and the staff of Indonesian Agroclimate and Hydrology Research Institute (IAHRI) and Indonesian Agricultural Environment Research Institute (IAERI) for their help in conducting farm survey in Jakenan, Central Java, Indonesia.

REFERENCES

1. Aldrian, E. and R.D. Susanto, 2003. Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature. Int. J. Climatol., 23: 1435-1452.
2. Boer, R., 2002. Analisis risiko iklim untuk produksi pertanian. Procedings of the Training of University Lectures of Sumatera and Kalimantan on Modeling, Agriculture and Environment Simulation, July 1-13, 2002, Bogor, Indonesia.
3. Las, I., 2008. Menyiasati fenomena anomali iklim bagi pemantapan produksi padi nasional pada era revolusi hijau lestari. Pengembangan Inovasi Pertanian, 1: 83-104, (In Indonesian).
4. Easterling, W.E., P.K. Aggarwal, P. Batima, K.M. Brander and L. Erda *et al*., 2007. Food, Fibre and Forest Products, in Climate Change 2007: Impacts, Adaptation and Vulnerability. In: Contribution of Working Group II to The Fourth Assessment Report of The Intergovernmental Panel on Climate Change, Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.)., Cambridge University Press, Cambridge, UK., pp: 273-313.
5. IPCC., 2007. Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge University Press, Cambridge, UK., ISBN-13: 9780521880107, pp: 7-22.
6. Estiningtyas, W., R. Boer, I. Las and A. Buono, 2012. Identification and delineation of drought area for climate risk management in Indramayu distric. J. Meteo. Geofis., 13: 19-20.
7. Harvey, C.A., Z.L. Rakotobe, N.S. Rao, R. Dave and H. Razafimahatratra *et al*., 2014. Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. Philos. Trans. R. Soc. London B: Biol. Sci., Vol. 369. 10.1098/rstb.2013.0089.
8. Wood, S.A., A.S. Jina, M. Jain, P. Kristjanson and R.S. DeFries, 2014. Smallholder farmer cropping decisions related to climate variability across multiple regions. Global Environ. Change, 25: 163-172.
9. Altieri, M.A. and P. Koohafkan, 2008. Farms: Climate Change, Smallholders and Traditional Farming Communities. Third World Network, Malaysia.
10. Schmidhuber, J. and F.N. Tubiello, 2007. Global food security under climate change. Proc. Natl. Acad. Sci. USA., 104: 19703-19708.

11. Muller, C., W. Cramer, W.L. Hare and H. Lotze-Campen, 2011. Climate change risks for African agriculture. Proc. Nat. Acad. Sci. USA., 108: 4314-4315.
12. Naylor, R.L., D.S. Battisti, D.J. Vimont, W.P. Falcon and M.B. Burke, 2007. Assessing risks of climate variability and climate change for Indonesian rice agriculture. Proc. Natl. Acad. Sci. USA., 104: 7752-7757.
13. Boer, R., K. Tamkani and A.R. Subbiah, 2003. Communicating climate forecast to farmers through climate field school: Indonesian experience. http://www.climateadaptation.net/docs/papers/Rboer-Subbiah%20paper.pdf
14. Tarrant, J., 2014. Mid-term evaluation of the climate services supporting adaptation in Indonesian food crops system: Technical report, No. AID-OAA-TO-11-00040, (WATER IQC II) Contract No. AID-EPP-I- 00-04-00024. United States Agency for International Development (USAID), USA.
15. Sopaheluwakan, A., 2011. Overview of climate services in Indonesia. Proceedings of the 2011 WMO RA-V Regional Seminar, November 2, 2011, Honiara, Solomon Islands.
16. Boling, A.A., B.A.M. Bouman, T.P. Tuong, M.V.R. Murty and S.Y. Jatmiko, 2007. Modelling the effect of groundwater depth on yield-increasing interventions in rainfed lowland rice in Central Java, Indonesia. Agric. Syst., 92: 115-139.
17. Makmur, E., 2009. Drought assessment over Indonesia related to El Nino and SSTA Indonesia. Proceedings of the Inter-Regional Workshop on Indices and Early Warning Systems for Drought, December 8-11, 2009, Lincoln, Nebraska.
18. Aldrian, E. and Y.S. Djamil, 2008. Spatio-temporal climatic change of rainfall in East Java Indonesia. Int. J. Climatol., 28: 435-448.
19. Ravindran, C.D., 2013. Use of rainfall analysis in the planning and management of rainfed cotton. CICR Technical Bulletin No. 15. http://www.cicr.org.in/pdf/rainfall_analysis.pdf
20. Vogel, C. and K. O'Brien, 2006. Who can eat information? Examining the effectiveness of seasonal climate forecasts and regional climate-risk management strategies. Climate Res., 33: 111-122.
21. Sayuti, R., W. Karyadi, Yasin and Y. Abawi, 2004. Factors Affecting the use of Climate Forecasts in Agriculture: A Case Study of Lombok Island, Indonesia. In: Using Seasonal Climate Forecasting in Agriculture: A Participatory Decision-Making Approach, Huda, A.K.S. and R.G. Packham (Eds.)., Vol. 59, Australian Centre for International Agricultural Research, Australia, pp: 52.
22. Rogers, E.M., 2010. Diffusion of Innovation. 4th Edn., Free Press, New York, USA., Pages: 518.
23. Traerup, S.L. and O. Mertz, 2011. Rainfall variability and household coping strategies in northern Tanzania: A motivation for district-level strategies. Regional Environ. Change, 11: 471-481.
24. Kassie, B.T., H. Hengsdijk, R. Rotter, H. Kahiluoto, S. Asseng and M. Van Ittersum, 2013. Adapting to climate variability and change: Experiences from cereal-based farming in the Central Rift and Kobo Valleys, Ethiopia. Environ. Manage., 52: 1115-1131.