Modelling and forecasting on paddy production in Kelantan under the implementation of system of rice intensification (SRI)

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ABSTRACT

The behaviour of the paddy total production and its future production depends on several important factors such as the water quality, the soil management and also the usage of proper field management system. The introduction of System of Rice Intensification (SRI) that was initiated in India has been brought over into Malaysia several years ago, although it is still not completely implemented, but it did show positive development, especially in land efficiency and production per hectare. Yearly paddy production data for the period of 1970-2009 of Kelantan were analysed by time series methods. Several individual forecasting methods such as Brown’s Double Exponential Smoothing, Linear’s Double Exponential Smoothing, Winter’s Multiplicative Exponential Smoothing, Damped Trend and Random Walk method were used to determine the best forecasting model for the data. The composite methods were calculated and computed under normalize weight method and fit regression weight method to obtain the best composite forecast method for the future paddy production analysis in Kelantan. Autocorrelation and several others measurements were used to determined the model efficiency and validity. The best methods will derives the best fit model for this study in determining the future of paddy production, while the implementation of SRI is one of the reasons in the contribution of the increases in productivity. The “best” forecasting model for this study is the composite forecast model of Holt’s Linear and Damped Trend Exponential Smoothing, which predicted a generally increasing pattern of Kelantan total paddy production for the next five years.

Key word: System of rice intensification (SRI), mean absolute percentage error (MAPE), rice yield prediction, exponential smoothing, combining forecasting.

INTRODUCTION

Rice is the traditional stable food in Southern Asian, and can assure food security at the family level, as well as at the national level. Agriculture, and mainly paddy cultivation and related jobs, contributes to the living of up to 75% of residents for certain area in Asian (e.g. Lower Mekong Basin), as reported in a research by Mizoguchi (2011). Rice is a versatile and rather easily grown crop, which actually grows on the soil type that is not suitable for the survivability of other crops, and areas that are water-logged or inundated. Paddy plant is robust towards pests, but it is quite sensitive towards weeds, especially lowland paddy. Traditionally, Southern Asian paddy cultivation system comprises of (i) upland (aerobic) rice, which grown in dry fields; (ii) lowland (wet or rain fed or irrigated) rice, which grown in inundated field for the major part of the cultivation period; (iii) deepwater or floating rice, which is growing in water depths between 0.5-4.5 m. According to Nielsen (2004), among all these three systems, lowland rice is by far the most important in terms of production and occupation in Malaysia. Rice has a relatively long shelf life, which can be stored up to several years. Although the prices of rice are relatively low in Asian, the commercial
At this juncture the System of Rice Intensification (SRI) came into light. SRI is considered to be a disembodied technological breakthrough in paddy cultivation according to Anthofer (2004). SRI involves the application of certain management practices, which together provide better growing conditions for rice plants, particularly in the root zone, than those for plants grown under traditional practices. This system seems to be promising to overcome the shortage of water in irrigated rice. SRI was developed in Madagascar in the early 1980s by Father Henride Laulanie, a Jesuit Priest, who spent over 30 years in that country working with farmers. It has since been tested in China, India, Indonesia, Philippines, Sri Lanka and Bangladesh with positive results. In Sri Lanka, SRI cultivation was practiced in 18 districts with encouraging results of doubling the yields. It was in practice in Cambodia, Indonesia, Laos, Myanmar, Philippines, Thailand, Vietnam, Bangladesh, China, India, Nepal, Sri Lanka, Gambia, Madagascar, Mozambique, Sierra Leone, Ghana, Benin, Barbados, Brazil, Cuba, Guyana, Peru and USA. Under SRI method of Rice cultivation, root development was more and healthy, tilling was almost double and the crop does not lodge. The grain weight was more and less incidence of pests and diseases were observed. This technology uses less quantity of inputs like water, fertilizers, pesticides etc. Paddy cultivation forms the basis of traditional Southeast Asian societies and the livelihoods of the people who comprise those societies. Historically speaking, paddy cultivation has always (at least for several millennia) been multifunctional—providing not only the raw material for subsistence and trade but also serving as the central focus for family and community life as well as spiritual and religious expression (Groenfeldt, 1990). Hence, the study of paddy production forecasting is not only important for the economical study, but also to the social development. This research mainly focuses in paddy production in Kelantan State, meaning the model is built only for the forecasting of Kelantan State future paddy production, and might not be suitable for other states. Besides that, the type of paddy is Oryza sativa L., out of 30 other Oryza species and the sub-species of Oryza sativa L. that are used for this data interpretation is Indica, instead of japonica and javanica (Sun, 2002). The assumption is made that all the paddy sub-species planted in Kelantan in Indica variety, as it is the most common and popular sub-species planted in Malaysia. According to the MARDI (2000), the sub-varietiy of Indica might defer from MR 219 to MR 249, but it is assumed that there are not much different between each of this hybrid species, although it might be a bit different in term of yield, but the different is considered as negligible. The main purpose of this study is to develop a models that not only best describes the behaviour of the paddy total production but is also capable of forecasting the future of paddy production with greater accuracy. The second purpose for this study is to determine the relationship between the implementation of SRI and the acceptance of planters in Kelantan for this cultivation method.

**METHODS AND MATERIALS**

The overall purpose of this research is to develop and validate an up-to-date model for paddy production forecasting with the correlation of SRI Implementation. The research will evaluate paddy production in Kelantan by using the past 40 years data which will be obtained from the Department of Agriculture (DOA) in Kelantan. There will be a total of 40 sets of data which representing the annual paddy production for the past 40 years respectively. The Unit of Agricultural Commodity Management in DOA will be assisting the data collection for the year 1970 to 2009. This research will focus on two main components: (i) the modelling and analysis methods of past forty year’s data of paddy production in Kelantan; (ii) the implication and factors in SRI towards the recent and future paddy production in Kelantan. The forecasting model is built based on the assumption of the implementation of System of Rice Intensification (SRI) has just started recently, hence, it is not suitable for any other place that is already implemented SRI for a long period of time, or not yet implemented at all. The scope of the research also mainly focuses on the agricultural management and practices, ignoring the social, economy and other aspect in the manipulation and interpretation of the data. In other word, this research views the factors that affect paddy production from agro-ecological aspect, without concern about human aspect, such as the hardworking or quality of human capital, as this human resource aspect regarding another field of study.

**Regression modelling**

Let the response variable (variable to be forecasted) be denoted by \( Y \) and the set of predictor variables by \( X_1, X_2, \ldots, X_p \), where \( p \) denotes the number of predictor variables. The true relationship between \( Y \) and \( (X_1, X_2, \ldots, X_p) \) can be approximated by a multiple linear regression model given by:

\[
Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p + \varepsilon
\]  
(Equation 1)

Where \( \beta_0 \) and \( \beta_i (i=1,2,\ldots,p) \) are parameters to be estimated and \( \varepsilon \) is a random error, while \( X_1 \) and \( X_i (i=1,2,\ldots,p) \) is the total production of paddy in Kelantan for year 1970-2009. Some assumptions are made about this model like the relationship of the respondent \( Y \) to the predictors \( X_1, X_2, \ldots, X_p \) is linear in the regression parameters \( \beta_1, \beta_2, \ldots, \beta_p \), the errors are assumed to be independently and identically distributed in normal random variables with mean zero and a common variance \( \sigma^2 \), the errors are independent of each
other (their pair-wise covariances are zero) and that the predictor variables $X_1$, $X_2$, ..., $X_p$ are non-random and measured without error.

**Exponential smoothing**

Pegels’ (1969) classification of exponential smoothing methods includes nine different methods. Each method is classified as being suitable for series with constant level, additive trend or multiplicative trend, and with either no seasonality, additive seasonality or multiplicative seasonality. Hyndman et al. (2002) have recently extended this taxonomy to include damped additive trend with either no seasonality, additive seasonality or multiplicative seasonality. From among the various methods, simple, Holt’s, damped Holt’s and Holt-Winters’ exponential smoothing have been very popular with practitioners and researchers. The Holt-Winters method with multiplicative seasonality has been widely used. Brown’s Simple Exponential Smoothing Model is one of the simplest methods for time series analysis. Initially, the time series data is denoted by $Y_1, Y_2, ..., Y_t$. Suppose we wish to forecast the next value of our time series $Y_{t+1}$ that is yet to be observed with forecast for $Y_t$ denoted by $F_t$. Then the forecast $F_{t+1}$ is based on weighting the most recent forecast $F_t$ with a weight of $(1-\alpha)$ where $\alpha$ is a smoothing constant/weight between 0 and 1. Thus the forecast for the period $t+1$ is given by:

$$F_{t+1} = F_t + \alpha (Y_t - F_t)$$  \hspace{1cm} (Equation 2)

Note that the choice of $\alpha$ has considerable impact on the forecast. A large value of $\alpha$ (say 0.9) gives very little smoothing in the forecast, whereas a small value of $\alpha$ (say 0.1) gives considerable smoothing. Alternatively, one can choose $\alpha$ from a grid of values (say $\alpha = 0.1, 0.2, ..., 0.9$) and choose value that yields the smallest Mean Square Error (MSE) value. If the model given earlier is expanded recursively then $F_{t+1}$ will come out to be a function of $\alpha$, past $Y_t$ values and $F_t$. So, having known values of $\alpha$ and past values of $Y_t$, our point of concern relates to initializing the value of $F_1$. Because the weight attached to this user-defined $F_1$ is minimal, its effect on $F_{t+1}$ is negligible. Holt’s Linear Exponential Smoothing Models will be one of the favourite to allow forecasting data with trends. The forecast for Holt’s linear exponential smoothing is found by having two more equation compared to Brown’s Simple Exponential Smoothing Model – one for level and one for trend. The smoothing parameters 9 weights $\alpha$ and $\beta$ can be chosen from a grid of value and then select the combination of $\alpha$ and $\beta$ which correspond to the lowest MSE. Multiplicative trend exponential smoothing has received very little attention in the literature. It involves modeling the local slope by smoothing successive ratios of the local level, and this leads to a forecast function that is the product of level and growth rate. Winter’s Multiplicative method is chosen as it is recommended when seasonality exists in the time series data. This method is based on three smoothing equations – one for the level, one for the trend, and one for seasonality. It is similar to Holt’s method, with one additional equation to deal with seasonality. In fact there are two different Winters methods depending on whether seasonality is modelled in an additive or multiplicative way. In this case, the multiplicative method is favourable.

**Forecasting performance criteria**

There are many criteria for the measurement of accuracy of a forecast but only few will be concern in this study. The criteria mentioned below are used for the comparison of among the individual forecast model as well as composite or combination forecast models. If $Y_t$ is the actual observation and $F_t$ is the forecast value of time, $t$ then $(Y_t-F_t)$ is called forecast error and denoted by $e_t$. To attain a sense of the dispersion of error, the mean square error or standard deviation of the error is examined. It is defined as:

$$MSE = \frac{\sum e_t^2}{n} \text{ for } t = 1, 2, ..., n$$  \hspace{1cm} (Equation 3)

A smaller value of mean square error is an indication of better model. MSE is an absolute measure, thus it does not facilitate comparison across time series and for different time interval. The root mean square error (RMSE) is obtained by taking the root of the MSE. The RMSE gives an indication of the standard deviation of the one step ahead forecast error. MSE and RMSE have the common drawback in that they are effected by the scale of the data and do not allow for comparison of different series or different time interval of the same series. A relative measure involves percentage error give a more valid basis for comparison. Mean Absolute Percentage Error (MAPE) defined as:

$$MAPE = \frac{\sum |e_t| / Y_t * 100}{n}$$  \hspace{1cm} (Equation 4)

MAPE is a scale resistant (unit-free) and can be used to compare across different time series model or for different time intervals for one same model. MAPE does not distinguish much between 2 different models, but it does indicate how large the forecast error is in comparison to the actual value of the series.

**RESULTS AND DISCUSSION**

The forecasting results can be divided into two parts which is the individual forecast models and the development of combination forecast models. Five individual forecasting methods namely the Brown’s Simple Exponential Smoothing, Holt’s Linear Exponential Smoothing, Winter’s
Multiplicative Smoothing, Damped Trend and Random Walk. The composite or combination forecasting method is proposed instead of choosing one from the five individual methods. Several methods of combination were used and the best method is determined through the resulting MAPE. In order to make it more comprehensive, a weighting method was used to determine the better MAPE reading. Weight is a column of the forecasting model table that contains the weight values for each model. The forecasts for the combined model are computed as a weighted average of the predictions from the models in the table using these weights. Models with missing weight values are not included in the forecast combination. The weight values were typed in these fields. Normalize Weights replaces each non-missing value in the Weights column with the current value divided by the sum of the weights. The resulting weights are proportional to original weights and sum to 1. On the other hand, Fit Regression Weights computes weight values for the models in the table by regressing the series on the predictions from the models. The values in the Weights column are replaced by the estimated coefficients produced by this linear regression. If some weight values are non-missing and some are missing, only models with non-missing weight values are included in the regression. If all weights are missing, all models are used.

From Table 1 it is clear that the average MAPE consistently declines as the number of methods increase, decreasing from MAPE = 8.49520 when \( P = 1 \) to 7.77100 when \( P = 5 \). This provides an indication of the increase in accuracy that might be gained from an increased in the number of methods. However, the reduction in MAPE decreases as \( P \) increases. This is the marginal impact of including an additional method decreases as the number of method increases. The best combination is not necessary from the high value of \( P \), but it is relevant with the low MAPE. So from the table, the lowest MAPE among all is from \( P = 2 \) from the combination of Holt’s Linear Exponential Smoothing and Damped Trend. The low MAPE indicates the “best” combination for each \( P \) and the high MAPE indicates the “worst” combination for each \( P \). When a single individual method is used, the risk of not choosing the best method can be very serious. When more methods are considered and their forecasts are averaged, the choice of the “best” method becomes less important in average. Table 1 shown that Damped Trend is the lowest MAPE individual method contributes in all combinations that give low MAPE. This proof that even if one method is superior, it may be possible to incorporate the information from the inferior forecast that performs better than either of the individual forecasts. Using the average of forecast is undoubtedly better than using a wrong model or single poor forecasting trend. An advantage of combining forecast is that when several methods were used, the result does not seem to be highly sensitive to the specific choice of the method. In conclusion, usage of a combined forecast is safer and less risky than relying on a single individual method.

This analysis is used to detect whether the expected value of Total Paddy Production is related to the value of Total Planted Area. An observed variation of 90.9% in Total Paddy Production is attributable to variation among predictions based on the value of Total Planted Area. Assuming that there is no relation between Total Paddy Production and Total Planted Area, there is a less than 1% chance of a proportion at least as large as this. This constitutes strong statistical evidence that the expected value of Total Paddy Production is related to the value of Total Planted Area.

The predicted regression model is:

\[
Y = -58002 + 4.104 (X)
\]

R Square = 90.93%
MAPE=8.66050

Where:

\[
Y = \text{Total Paddy Production}
\]

\[
X = \text{Total Planted Area}
\]

From Table 2, it is obvious that the Holt’s Linear + Damped Trend Exponential Smoothing Composite Method of forecasting is the “best” model for this study, with the lowest MAPE reading among all the other “best” model in different groups. Further research can go through for a more comprehensive analysis and model development via artificial intelligent modelling technology.

Key element of SRI

1. **Young seedlings.** If establishing the rice crop by transplanting, start by using single seedlings preferably 8 to 12 days old, and certainly less than 15 days, that is before the start of the 4th phyllochron. The objective is to preserve the plants’ vigour and growth potential for tillering and root development which is forfeited by using older seedlings beyond their 4th phyllochron of growth (Stoop et al., 2002).

2. **Careful transplanting of single seedlings.** The transplanting of single seedlings, instead of a clump of several seedlings, this should be done quickly, within 30 min after the seedlings are removed from the nursery, and carefully, keeping soil and seed sac attached to the root, putting the roots very shallow (1-2 cm), without inverting the root tips by pushing them straight down into the soil as this will set back their resumption of growth. Careful handling of seedlings avoids desiccation and trauma to the roots, with little or no interruption of plant growth and no ‘transplant shock’.

3. **Wider square spacing.** This is important for better growth of roots and canopy. We noted earlier the recommendation of one plant per hill established in a square pattern, starting out usually with 25×25 cm
Table 1. Low, average and high MAPE (%) for all possible number of methods.

<table>
<thead>
<tr>
<th>No. of methods</th>
<th>Lowest MAPE</th>
<th>Average MAPE</th>
<th>Highest MAPE</th>
<th>Lowest MAPE methods among group</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = 1</td>
<td>7.88566</td>
<td>8.49520</td>
<td>9.66602</td>
<td>Damped Trend</td>
</tr>
<tr>
<td>P = 2</td>
<td>7.50884</td>
<td>7.89323</td>
<td>8.55937</td>
<td>Holt’s Linear + Damped Trend</td>
</tr>
<tr>
<td>P = 3</td>
<td>7.53587</td>
<td>7.82275</td>
<td>8.30890</td>
<td>Holt’s Linear + Random Walk + Damped Trend</td>
</tr>
<tr>
<td>P = 4</td>
<td>7.58631</td>
<td>7.82105</td>
<td>8.14912</td>
<td>Brown’s Double + Holt’s Linear + Winter’s Multiplicative + Damped Trend</td>
</tr>
<tr>
<td>P = 5</td>
<td>7.57138 (NW)</td>
<td>7.77100</td>
<td>7.97055 (FRW)</td>
<td>5-in-1 NW method</td>
</tr>
</tbody>
</table>

Note: NW: Normalize Weight Method, FRW: Fit Regression Weight Method.

Table 2. The Comparison of the lowest MAPE among the group of model used for this study.

<table>
<thead>
<tr>
<th>Methods used</th>
<th>MAPE Reading</th>
<th>Trend of paddy production in future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Exponential Smoothing Method</td>
<td>7.88566</td>
<td>Increases</td>
</tr>
<tr>
<td>Damped Trend</td>
<td>7.50844</td>
<td>Increases</td>
</tr>
<tr>
<td>Composite Exponential Smoothing Method</td>
<td>8.66050</td>
<td>Increases</td>
</tr>
<tr>
<td>Holt’s linear + Damped Trend</td>
<td>7.57138 (NW)</td>
<td>Increases</td>
</tr>
<tr>
<td>Regression Modelling Method</td>
<td>7.77100</td>
<td>Increases</td>
</tr>
</tbody>
</table>

distances between rows and hills. It is counterintuitive that reducing plant populations by as much as 80-90% can give higher yield, but this is the result, provided that the other SRI practices are also followed. The higher yield with reduce population results from the increase in panicle-bearing primary tillers per unit area, and also more spikelets and filled grains per panicle, as well as usually higher grain weight.

4. Aerobic soil conditions. Using very young seedling has been shown in factorial trials to be the single most important contributor to higher SRI yields (Randriamiharisoa and Uphoff, 2002), but the second most important is keeping the paddy soil moist but not continuously saturated. This avoids the suffocation and degeneration of rice plant roots (Kar et al., 1974) and also supports more abundant and diverse populations of aerobic soil organisms that provide multiple benefits to the plants (Ramasubramanian, 2006).

5. Active soil aeration. Not flooding fields is conducive to passive soil aeration, letting biological processes improve soil structure and functioning. Beyond this, SRI promotes mechanical measures to aerate the soil. When paddy fields are not kept continuously flooded, weed growth becomes a greater problem. While weeds can be controlled by manual weeding or chemical herbicides, neither gives as good results with SRI practices as the use of a soil-aerating hand weeder which breaks up the surface soil as it turns weeds into mulch, conserving their nutrients as they decompose in the soil. Mechanical weeding should begin about 10-12 days after transplanting, moving preemptively against weeds.

6. Enhanced soil organic matter. Initially, SRI was developed in the 1980s with mineral fertilizer being used to boost soil fertility, because this was thought necessary to improve yields on the very poor soils in Madagascar. At the time, government subsidies made fertilizer affordable to poor farmers. But when these subsidies were eliminated, SRI practice was shifted to rely on compost made from rice straw and any other available biomass. It turned out that what was considered second-best gave even better results, with less out-of-pocket cost. This has been confirmed by factorial trials (Randriamiharisoa and Uphoff, 2002).

Hindrance of SRI Implementation in Kelantan

Despite its success in an increasing number of settings in India and several other countries, the SRI method has not yet become a major method of cultivation. Given below are some of the principal reasons:

1. Resistance to accept SRI: Many agricultural establishments are still reluctant to recognize the potential of SRI. Preferences remain for emphasizing varietal improvement. Hybrid rice, for instance, which could result in 15-20% yield increases, but with higher costs, continues to receive major attention and publicity.

2. Lack of training and extension facilities: Training and extension facilities are not in place in many countries for
SRI. Malaysia is currently begun to develop special programs and centre but it is still not effective.

3. Absence of precise water management: There are certain technological and institutional limitations when it comes to adoption of the SRI method, as it requires reliable delivery of small and regulated amounts of irrigation water.

4. Erratic power supply: Farmers cultivating rice with their own water pumping facilities (bore well, dug wells, small lifts, etc.) find SRI attractive, especially in countries like Malaysia; but constraints like failure or improper electricity supply can be a disincentive because they interfere with precise and timed water delivery.

5. No scope for company profits: As SRI is currently in the public domain, with no claims of intellectual property rights, the process of spreading its benefits could not be monopolized by anyone. This has reduced incentives for private promotion of SRI. Currently, there are no interest groups such as those prevailing for seed companies, fertilizer companies, etc. for promoting SRI. Some have a vested interest in maintaining the status quo.

6. Lack of proper information: Early reports about SRI created some very high expectations with regard to yield increases. This did not translate to all farmers achieving the reported yield levels, and eventually some lost interest and discontinued. There was no way to make such farmers understand that SRI results are driven not by changes in a genetic ‘blueprint’ or external inputs, but by mobilization of endogenous processes and potentials within the plant and soil systems.

Although SRI is just been newly introduced in Malaysia, and it has not been completely implemented, it is already showing a very positive increase of paddy production compared to the past. The main reason for the SRI implementation not been used worldwide is the human factors. Farmers tend to reject new cultivation method and do believe in their traditional method. Further research and advises with clear evidence should be done in Malaysia for the farmer to have a clear confident in this SRI cultivation method transformation in order to boast the production of paddy, especially in Kelantan which is considered as a major agricultural industry contributor in Malaysia. SRI is being continually improved, particularly at farmer initiative, although the scientific community has growing interest in the involvement with SRI. The benefits obtainable for small farmers as well as for the environment are driving this continuous innovation. Potential for further improvement exists in minimizing puddling or doing away with it altogether, introducing direct seeding, increasing biomass production within the cropping system through high-biomass mulch and cover crops, and transforming the total rice-based cropping system to Conservation Agriculture. There are opportunities for development-oriented research to improve equipment and practices for direct seeding, weed management, for residue and soil cover management, for nutrient and water management and for cropping pattern management. In irrigated rice, there are potentials for significant water savings through SRI, and in case of irrigation expansion for rice production, SRI-based systems offer higher return to investment to the farmers and at the scheme level to governments. Policy support to promote SRI has been slow in coming, but this is beginning to change. Policy and institutional changes can be accelerated if the scientific and donor community can be made aware of the full potential of SRI methods for sustainable production intensification, reducing energy and production costs, responding to climate change, saving water, and reducing the consumer price of rice.

Conclusion

The Exponential Smoothing Methods can be well implemented into this study for forecasting the yearly total paddy production of Kelantan based on the data collected for the period of 1970-2009. A simple preliminary study of data set has goes through and it indicated that the existence of trend, seasonal effect of the data. All of the characteristic will be used as the parameter for model development choice consideration. In comparison with and between the different individual methods, Damped Trend Exponential Smoothing method outperformed other model by using the MAPE as reference. While on further study, the use of composite forecast method has successfully improved the accuracy of the forecasts, and by using MAPE and fit regression weight method, the “best” forecasting model for this study is the composite forecast model of Holt’s Linear and Damped Trend Exponential Smoothing. This “Best Model” predicted a generally increasing pattern of Kelantan total paddy production for the next five years, although the software is able to forecast until the year of 2012, but it is not recommended to use as a reference.

The clear limitation of the study is the number of observation available for the study is too little, hence, only short term forecast can be done and the first few years forecasting can be used as the reference. Furthermore, the implementation of SRI is a recent cultivation technique, which is not implemented totally and not existing in the past 30 years, so this causes the limitation of this study as well. This study is also limited to only the combination of forecast from different single-series projection methods. Other types of forecasts have also been successfully included in composite model, but it is not included here. Another limitation is only the MAPE, RMSE, and MSE is included in composite model, but it is not included here. The forecast only focuses on the paddy production without taking the environmental and social factors into consideration by assuming these factors are negligible or have little effect on the production.

Due to the limited time and several other factors such as lack of expertise, lack of personal statistical knowledge, as well as data, the study is still having a great room to be
further on and making a more thoroughly study, both forecasting modeling as well as the SRI implementation. The introduction of Artificial Intelligent (AI) modeling and other advance mathematical models might give rise of the better and more complete result and analysis. It is also notable to divide the study on Main and Off Season Paddy Production and Planted Area for a more comprehensive and deeper study on the paddy production in Kelantan. The
time limit and the incompleteness of data create the constraints for further study. For the implementation of SRI, it is still a brand new field to be considered in Malaysia, especially in Kelantan. Hence, the lack of information and the limitation of farmer’s mentality have contributed to the SRI implementation and research. It is recommended to combine the study from several Universities such as University of Putra Malaysia (UPM), which is considered as a Research University and focuses on agriculture development.

REFERENCES


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