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# THE INFLUENCE OF INTEGRATED CROP MANAGEMENT ON THE HOUSEHOLD FOOD SECURITY OF MAIZE FARMERS IN WEST JAVA INDONESIA

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**Abstract**

*Implementation of Integrated Crop Management (ICM) on maize farming is expected to increase the production and household income. Household income was used for accessing food in order to achieve household food security. This study aimed to analyze the influence of the implementation of ICM on food security and to identify the socio-economic factors that affect the levels of food security among maize farmer households. The study was conducted in the maize production center in West Java Province, in Sukabumi and Garut Regencies. The stratified random sampling method was used to survey 300 households in 2015. Household food security was measured by cross-classification of the share of food expenditure and consumption of energy. The socio-economic factors that affected household food security levels were estimated using ordered logistic regression. The results showed that in aggregate the level of households maize farmers food security was insufficient. The analysis showed that factors influencing maize farmerhouseholds were family size, age of housewife, vegetable prices, income from maize farming, the technical efficiency of maize farming, and the dummy variable of the farmer.*

**Keywords:** *Food security, households, integrated crop management (ICM), maize farming*
**JEL Codes:** O30, Q12, Q16, Q18, Y40

## 1. Introduction

Food security is a series of three main components, namely food availability and stability, food accessibility, and food utilization (FAO, 1996). Adequate food production and availability at national and provincial level do not automatically guarantee food security at household and individual level. Food securityat household level represents the households' ability to fulfill their need for food. This ability is influenced by many complex factors but is generally related to changes in the aspects of food production, food consumption and household resource allocation behavior.

Food accessibility is the household's ability to obtain enough food, either from self-production, purchasing, bartering, gifts, loans, or food aids. Food availability at thenationallevel cannot guarantee food sufficiency at thehousehold or individual level. Food availability and accessibility which are physical and economic dimensions are important determinants of food security (Braun *et al.*, 1993; Sen, 1981; Simatupang, 2007; Maxwell, 1996).

Maize (*Zea mays*) is one of the main food crops aside from rice and soybeans (Rusastra *et al.* 2004) which is potential and has a high economic value. Maize is also a strategic commodity for Indonesia because of its role in fulfilling food, feed, and other industrial needs. The role of maize in Indonesia's national economy, especially in rural areas, is also important because maize-farming households are the second largest after rice-farming households at 6.71 million households (37.63%) out of the 17.83 million rice, seasonal crop and sugar cane farming households. This role is even more important if the multiplier effect of the maize agribusiness is considered (Directorate General of Food Crops, 2010).

In the period 2009-2015,the Indonesian average national maize annual production, productivity and harvest area were 1.57%, 3.10%, and -1.56%, respectively. The increased production was not a result of an increased farming area but a result of the application of cultivation technology. West Java Provinceis one of the national maize production centers where in the period 2009-2014 the average annual growth of the maize harvest area, production, and productivity had positive values at 0.68%, 5.14%, and 5.71%, respectively. Maize plants in West Java Provinceare mostly cultivated on dry land (89%) and the remaining 11% is planted on paddy fields. There is still potential for maize cultivation development in West Java Province because there is agricultural land available for the maize agribusiness, as the 2012 statistical data stated that there was 9.43 thousand ha. of paddy field land and 1.53 million ha. of dry land available (West Java CBS, 2012).

Technically, the efforts to improve maize production in Indonesia have been made through increasing both the size of the cultivation area and the productivity. Coelli *et al.* (1998) stated that there are three sources of productivity growth,technological change, improvement of technical efficiency, andbusiness scale. A number of main issues in maize cultivation are (1) the small and scattered land ownership pattern; (2) the less intensive agribusiness system due to the farmers' lack of capital; (3) stagnation of the cultivation technologyfor a number of food crop commodities; (4) the relatively low level technical efficiency, allocative efficiency, and the economic efficiencyachieved by a number of food crop commodities; and (5) weakness in institutional consolidation at farmer level.

One of the methods in the effort to achieve increased maize productivityis the application of Integrated Crop Management (ICM) for maize through Farmers Field Schools. The maize ICM consists of two components of technology namely the basic technology components and the elective technology components. The basic technology components include (a) the use of novel, hybrid, or composite varieties, (b) superior and labeled seed, (c) populations of between 66,000 and 75,000 plants/hectare, and (d) fertilizing based on plant needs and soil nutrient status. On the other hand, the elective technology components are soil preparation, the construction of drainage channels, the application of organic matter, embanking, weed control through mechanical means or contact herbicides, pest and disease control, and harvesting on time and immediate drying.

The application of ICM at farmer level has been proven to improve productivity, technical efficiency, and farmer income (Haryani, 2009; Tamburian *et al*, 2011; Syuryawati *et al.*, 2013; Asnawi, 2014; Sumarno*et al.*, 2015). This study aimed to analyze the effect of the application of ICM technology on food security and what factors influence the level of maize farmer household food security.

## 2. Methodology

### 2.1. Theoretical Framework

Assessment of food security at household level was conducted by identifying two indicators: adequate caloric intake (kcal) and the food expenditure share. This was based on the cross-classification used by Jonsson and Toole in Maxwell *et al.* (2000) that can be seen in Table 1 where 80 percent of the energy consumption (per adult equivalent unit) would be combined with a food expenditure share of > 60 percent of the total household expenditure, resulting in the following criteria :

**Table1. Assessment of the Household Food Security Level**

| Consumptionof energy per adult equivalent unit | Food Expenditure Share | |
|---|---|---|
| | Low<br>(≤ 60% of the total expenditure) | High<br>(> 60% of the total expenditure ) |
| Adequate<br>( > 80% of theenergy requirement) | Secure (4) | Vulnerable (3) |
| Lacking<br>(≤ 80% of the energy requirement) | Less secure (2) | Insecure (1) |

The food expenditure share is: (1) low if it is ≤ 60% and (2) high if it is > 60%. The energy consumptioncategory: (1) adequate if it is > 80% of the energy requirementand (2) lacking if it is ≤ 80% of the energy requirement. The per capita average daily energy requirement at consumption level according to the Republic of Indonesia’s Minister of Health’s Regulation Number 75/2013 is 2,150 kcal.

The food security category: (1) a household is secure if the share of food expenditure is small (≤60 percentof the household expenditure) and consumes adequate energy (> 80 percentof the energy requirement), (2) a household is vulnerableif the share of food expenditure is large (> 60 percent of the household expenditure) and consumes adequate energy (> 80 percent of the energy requirement), (3) a household is less secureif the food expenditure is small (≤ 60 percentof the household expenditure) and does not consume adequate energy (≤ 80 percent of the energy requirement), and (4) a household is insecure if the proportion of food expenditure is large (> 60 percent of the household expenditure) and does not consume adequate energy (≤ 80 percent of the energy requirement).

The estimation of household food security level was analyzed using an ordered logistic regression model. This model modified a model that had been used by Bogale and Shimelis (2009) and Demeke *et al.* (2011) The ordered logistic regressionis a regression with response variables which are categorical and ordered. The logistic model for the ordered response data with the c category (c>2 ) is an expansion of the logistic model for nominal response data with two categories (a binary logistic model). The logistic model for ordered response data is also known as the cumulative logit model. The response in the cumulative logit model is in the form for ordered data which are represented by the numbers 1, 2, 3,…, c, where c is the number of response categories. The cumulative logit for each category j is defined as:

$L_j(x) = ln\ \left(\frac{F_j(x)}{1- F_j(x)}\right)$with j = 1, 2, .............. c-1 (1)

The model which uses all the cumulative logits simultaneously can be formulated as:

$\hat{L}_j(x) = \ \hat{\alpha}_j + \hat{\beta}_x$ (2)

Each cumulative logit has its own intercept. $\hat{\alpha}_j$and$\hat{\beta}$ are estimators with the maximum likelihood method for each $\hat{\alpha}_j$and β'. The estimation value for P $P(Y \leq j|x)$can be broken downby inverse transformation of the cumulative logit function:

$P(Y \leq j|x) = \left(\frac{\exp(\hat{\alpha}_j + \hat{\beta}'_x)}{1+\exp(\hat{\alpha}_j + \hat{\beta}'_x)}\right)$with j = 1,2,......c-1 (3)

$P(Y \leq j|x) = \left(\frac{1}{1+\exp(-\hat{\alpha}_j - \hat{\beta}'_x)}\right)$so that (4)

$P(Y \leq j|x) = \left(\frac{1}{1+\exp(\hat{L}_j(x))}\right)$ (5)

**2.2. Location and Time of Study**

The study location was in West Java Province considering the fact that West Java Provinceis one of the maize ICM locations. The determination of the regencies and districts was conducted through purposive sampling by considering the size of the harvest area, the number of farmers, the number of maize ICM locations, and the ICM site criteria. Two regencies were selected as the study location i.e. Sukabumi Regency and Garut Regency. The study was conducted between April and June 2015.

**2.3. Sampling Method**

Samples were collected using the stratified random sampling technique where the respondent farmers were first classified into maize ICM program participants and non-maize ICM program participants with the determination that each population had an equal chance of becoming a sample. Farmers who were maize ICM program participants were both those who were participating in the ICM program (on going) and those who were the ICM program alumni. There were 300 maize farmer respondents as samples (162 ICM farmers and 138 non-ICM farmers).

**2.4. Empirical Model**

Estimation of the factors that influenced household food security at farmer level was conducted using an ordered logistic regression model:

$$Ln \Pr(y_i = i) = ln \propto + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 + \beta_7 \ln x_7 + \beta_8 \ln x_8 + \beta_9 \ln x_9 + \beta_{10} \ln x_{10} + \beta_{11} \ln x_{11} + \beta_{12} \ln x_{12} + \lambda D + \mu \quad (6)$$

Where:

$\Pr(y_j = i)$ =was the probability of the category of household food security degree (1 = insecure, 2 = less secure, 3 = vulnerable,and4 = secure; α = intercept; β = regression coefficient(the parameter being estimated) (i = 1 s/d 12); λ = regression coefficient of the dummy variable (the parameter being estimated) (i = 1); μ =error term; $X_1$ =the number of household members (people); $X_2$ = the housewife's education level (years); $X_3$ = the housewife's age (years); $X_4$ = the price of rice (IDR/kg); $X_5$ = the price of sugar (IDR/kg); $X_6$= the price of vegetables (IDR/kg); $X_7$ = the price of fish (IDR/kg); $X_8$ = the price of eggs (IDR/kg); $X_9$ = the price of instant noodles (IDR/pack); $X_{10}$ = income from maize farming

(IDR/year); $X_{11}$ = total household income (IDR/year); $X_{12}$ = maize production technical efficiency level (%); D = the farmer dummy variable (0 = non ICM farmers, 1 = ICM farmers)

## 3.Results and Discussion

### 3.1. The Food Expenditure Share, Energy Sufficiency, Food Security Level

Generally, household expenditure is divided into two categories i.e. food expenditure and non-food expenditure. Household expenditure is one of the indicators of people welfare. Households with a large food expenditure share are classified as households with relatively poor welfare compared to households with a small food expenditure share (Ilham and Sinaga 2007).

Table 2 shows that ICM farmers (79.63%) and non-ICM farmers(61.60%) have small food expenditure shares (≤ 60%) andthe remaining 20.37% and 38.41%, respectively, have large food expenditure shares (more than 60%). In aggregate, 28.67% of the farmers have large food expenditure shares (more than 60%), while the rest, 71.33%, have small food expenditure shares (≤ 60%).

**Table2. The Distribution of Maize Farmer Household Food Expenditure Shares in West Java Province**

| Category | ICMFarmers | | Non-ICMFarmers | | Both types of farmers | |
|---|---|---|---|---|---|---|
| | Number of households | % | Number of households | % | Number of households | % |
| Low 30% - 50% | 50 | 30.86 | 40 | 28.99 | 90 | 30.00 |
| 51% - 60% | 79 | 48.77 | 45 | 32.61 | 124 | 41.33 |
| High 61% - 80% | 29 | 17.90 | 45 | 32.61 | 74 | 24.67 |
| 81% - 99% | 4 | 2.47 | 8 | 5.80 | 12 | 4.00 |
| Total | 162 | 100 | 138 | 100 | 300 | 100 |

Source: Primary Data

The distribution of maize farmers' household energy requirement (Table3) shows that 84.57% or 137 ICM farmers households were classified as lacking in energy consumption (below 80%) and the remaining 15.43% or 25 households consumed enough energy (above 80%). There was 6.17% of the households that consumed more than 100% of the energy requirement. On the other hand, there were 127 households or 92.03% of non-ICM farmer households that lacked in energy consumption while 7.97% or 36 households consumed enough energy and 15 of these consumed more than 100% of the energy requirement. In aggregate, 88% or 264 farmer households fulfilled less than 80% the required energy, whereas the remaining 12% or 36 farmer households fulfilled their energy requirement (more than 80%) with 15 farmer households consuming enough energy, exceeding 100% of the daily requirement.

**Table3. The distribution of maize farmers' household energy requirement in West Java Province**

| Category | ICM Farmers | | Non-ICM Farmers | | Both types of farmers | |
|---|---|---|---|---|---|---|
| | Number of households | % | Number of households | % | Number of households | % |
| Lacking< 60% | 117 | 72.22 | 116 | 84.6 | 233 | 77.67 |
| 60% - 80% | 20 | 12.35 | 11 | 7.97 | 31 | 10.33 |
| Adequate 81% - 100% | 15 | 9.26 | 6 | 4.35 | 21 | 7.00 |
| < 100% | 10 | 6.17 | 5 | 3.62 | 15 | 5.00 |
| Total | 162 | 100 | 138 | 100.00 | 300 | 100.00 |

**Source:** Primary Data

The distribution of household food security levels (Table4) show that 18 ICM farmer households or 11.11% were classified as secure, 9 households or 5.56% were classified as vulnerable, 111 households or 68.52% were classified as less secure, and 24 households or 14.81% were classified as insecure. On the other hand, there were 6 non-ICM farmer households or 4.35% that were classified as secure, 5 households or 3.62% classified as vulnerable, 77 households or 55.80% classified as less secure, and 50 households or 36.23% classified as insecure. In aggregate, the household food security levelof maize farmers in West Java Province was 188 farmer households were classified as less secure (62.67%), 74 farmer households insecure (24.67%), 24 farmer household secure (8%) and 14 farmer households vulnerable (4.67%). Therefore, in aggregate, the farmers' household food security level was dominated by those classified as less secure.

**Table4. The Distribution of Household Food Security Levels of Maize Farmersin West Java Province**

| Food security level | ICM Farmers | | Non-ICM Farmers | | Both types of farmers | |
|---|---|---|---|---|---|---|
| | Number of households | % | Number of households | % | Number of households | % |
| Secure | 18 | 11.11 | 6 | 4.35 | 24 | 8.00 |
| Vulnerable | 9 | 5.56 | 5 | 3.62 | 14 | 4.67 |
| Less secure | 111 | 68.52 | 77 | 55.80 | 188 | 62.67 |
| Insecure | 24 | 14.81 | 50 | 36.23 | 74 | 24.67 |
| Total | 162 | 100 | 138 | 100 | 300 | 100 |

**Source:** Primary Data

### 3.2. Factors Influence Household Food Security

The results of the ordered logistic regression model test in Table 5 demonstrated that the Pseudo $R^2$value was 0.396. This means that the independent variables could only explain the dependent variablesby 39.6 percent, the remaining 60.4 percent was explained by variables not included in the model. The ordered logistic regression assumption requires independent variables to be free from multicollinearity. The independent variables in the model with 4 categories of food security had a Variance Inflation Factor (VIF) of less than 10 (1.018 – 2.671) anda tolerancegreater than 0.1 (0.374 - 0.982) so that between independent variables there was no multicollinearity.

The Chi-Squarein the LR (Likelihood Ratio) for 4, 3, and 2 categories were each 124.640, 109.353 and 90.250, respectively. Therefore, the ordered logistic regression model used was the model with 4 categories of food security, namely secure, vulnerable, less secure, and insecure.With α=5 % of the LR statat 0.000 which means that $H_o$was rejected (the model with independent variables was better than the model without independent variables or the model with just intercepts). This means that in aggregate the independent variables of number of household members, the housewife's education level, the housewife's age, the price of rice, the price of sugar, the price of vegetables, the price of fish, the price of eggs, the price of instant noodles, income from maize agriculture, the total household income, the maize production technical efficiency level, and the farmer dummy variables,had a significant effect on the household food security levelof maize farmers.

The result of the food security level analysis with 4 categories was that there were 3 limits namely limit 1 (constant 1) which was insecure, limit 2 (constant 2) which was less secure, limit 3 (constant 3) which was vulnerable with the secure comparison. With the *ceteris paribus* assumption, the probability of maize farmers' household food security level at various levels was (a) Pr (insecure ≤ 33.982); (b) Pr (33.982 ≤ less secure ≤ 38.208); (c) Pr (38.208 ≤ vulnerable ≤ 38.911); and (d) Pr (secure ≥ 38.911).

**Table5. The Estimation Results of the Factorsthat Influenced the Level of Maize Farmer Household's Food Security in West Java Province**

| Variable | Coefficient | Standard error | Wald | Sig | Odds-ratio |
|---|---|---|---|---|---|
| Constant (1) | 33.982** | 14.702 | 5.342 | 0.011 | |
| Constant (2) | 38.208*** | 14.743 | 6.716 | 0.005 | |
| Constant (3) | 38.911*** | 14.749 | 6.960 | 0.004 | |
| Ln the number of household members | -3.778*** | 0.480 | 62.04 3 | 0.000 | 0.023 |
| Ln the housewife's level of education | 0.045$^{ns}$ | 0.128 | 0.125 | 0.362 | 1.046 |
| Ln the housewife's age | 1.054** | 0.551 | 3.667 | 0.028 | 2.869 |
| Ln the price of rice | -0.530$^{ns}$ | 1.202 | 0.194 | 0.330 | 0.589 |
| Ln the price of sugar | 0.008$^{ns}$ | 0.027 | 0.094 | 0.380 | 1.008 |
| Ln the price of vegetables | 1.552** | 0.693 | 5.009 | 0.013 | 4.721 |
| Ln the price of fish | -0.580$^{ns}$ | 0.552 | 1.103 | 0.147 | 0.560 |
| Ln the price of eggs | -0.016$^{ns}$ | 0.030 | 0.276 | 0.300 | 0.984 |
| Ln the price of instant noodles | 0.020$^{ns}$ | 0.036 | 0.323 | 0.285 | 1.02 |
| Ln income from maize agriculture | 0.399* | 0.251 | 2.530 | 0.056 | 1.490 |
| Ln total household income | 1.160*** | 0.443 | 6.848 | 0.005 | 3.190 |
| Ln maize production technical efficiency level | 1.258* | 0.859 | 2.146 | 0.072 | 3.518 |
| Farmer dummy | 0.718*** | 0.291 | 6.084 | 0.007 | 2.050 |

**Source :** Primary Data

**Note** : *** = Significant at α=1%,** = Significant at α=5%, Significant at α=10%

Based on the estimation results in Table 5, it could be seen that the variables that influenced household food security level were the number of household members, the total household income, and the farmer dummy($\alpha = 1\%$),the housewife's age and prices of vegetable variables ($\alpha = 5\%$),and the income from maize agriculture and maize production technical efficiency level variables ($\alpha = 10\%$).

The number of household members significantly influenced the food securitylevel with a negative coefficient, meaning that an increase in the number of household members would reduce the probability of household food security. The odds ratio demonstrated that for every increase in the number of household members, there will be a decrease in the probability of food security by 0.023 times. This result was supported by the results of the studies conducted by Nurlatifah (2011), Manaf (2012), Wulandari (2013), Suharyanto (2014), and Ibok *et al.*(2014).

The total household income had a positive and significant effect on the level of food security with an odds ratio of 3.190. If there was an increase in the total household income, the household's access to food would increase as much as the odds ratio value. This result was supported by the results of the studies conducted by Hutapea (2014), January (2014) and Abu (2016).

The logit coefficient for the farmer dummy was also positive with an odds ratio of 2.050. The probability of maize ICM farmers increasing their household food security level was 2.050 times more than that of the non-ICM farmer household. By enrolling the farmers in the maize ICM program through the Field School, farmers are expected to be able to apply the ICM technology components in their agribusiness practices so that they could improve their maize productivity and their income from maize agriculture.

The housewife's age had a positive and significant effect on the level of food security. This was supported by the study by Junaidi *et al.* (2014). The average age of housewives was 44.17 years with the highest range in the 31-50 year age group at 64% and they were still within the productive age group. Housewives have a strategic role in the realization of family food security because they manage food consumption and food expenditure, and they contribute additional income. The management of food consumption determines the family food diversification. At a productive age, a mother could realize food security through her efforts to diversify food to ensure that the family's nutritional requirements are fulfilled and is supported by an adequate household income.

The variable logit coefficient of the maize production technical efficiency level was positive with an odds ratio of 3.518. This means that if there was an increase in maize production efficiency, it would increase the household food security level by 3.518 times. In accordance with the aim of the maize ICM program, the technical efficiency of maize agribusiness is expected to increase.

The price of food is closely related to the household's economic accessibility in determining the level of food security (Lokollo *et al.,* 2007, Rachman, 2010). From the six food price variables in the model, the price of rice, sugar, fish, eggs, and instant noodles variables did not significantly affect the households' food security level probability. On the other hand, the prices of vegetable variable significantly affected the food security level probability. The price ofrice, fish, and eggs variables had negative logit coefficients which means that if there was an increase in the prices of these foods, it would decrease the probability of the household food security level as much as the odds ratio. However, the price of sugar, vegetables and instant noodles variables had positive logit coefficients, meaning that if there was an increase in the price of these foods, it would increase the probability of the households' food security level.

The price of vegetables significantly increased the probability of household food security; this was supported by the results of the studies by Sianipar *et al.* (2012) and Hutapea (2014). The food consumption pattern at farmer level demonstrated that households consume a lot of vegetables in the form of either stir-fries or fresh vegetables. The types of vegetables that were consumed were water spinach, cabbage, mustard greens, string beans, yardlong beans, vegetable tomatoes, carrots, cucumbers, cassava leaves, aubergines, bean shoots, red chili peppers, and bird's eye chili peppers.

## 4. Conclusion and Policy Implications

The conclusions of this study are in aggregate, the maize farmer's household food security level in West Java Province is less secure. The implementation of ICM maize farming was significanly improve of the food security level of both (secure and vulnerable) from 7.97% to 16.67%. In addition, the insecure category reduce from 36.23% to 14,81%, due to implementation of ICM maize farming (compared to non-ICM maize farming)The housewife's age, the price of vegetables, income from maize agriculture, the total household income, the maize production technical efficiency level, and farmer dummy had positive effects on the household food security level. ICM on maize farming was a strategic programme and enhancing its technical efficiency will improve its performance as well as it is achievement in household food security

The household food security levelof ICM farmers was higher than non-ICM farmers, meaning that the replication ICM programme will give positive impact on in improving farmer income as well as household food security of the farmers

The policy implications : (1) in order to realize household food security, the most important issues that need to be addressed are increasing household accessto food as one of the food security pillars. Food accessibility could be increased through increased household income (on-farm and off-farm), (2) increasing agricultural production can be achived through the application of cultivation technology, production markets, established selling prices, affordable production input prices which are available at appropriate times is an incentive for farmer households to increase production, and (3) in addition, improving the farmer household's access to off-farm job opportunities needs to be done through human resource improvement through the improvement of formal education and non-formal education for housewives. The respective policy instrument is important in improving their knowledge pertaining to the utilization, diversification, and quality of family food consumption to improve household food security.

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