本研究では、インドネシアのコメと畑作物に焦点を当て、環境変化や価格変動に対する農家経済行動を分析した。まず、単収変化を作付面積の変化と生産量の変化に分離し、エルニーニョ現象時の大作付面積の変化を分析した。次に、作付面積と市場価格との関係を時系列モデルから特定し、市場価格が作付面積に与える影響を定量的に分析した。その分析結果を、既存の作付体系や流通制度の視点から考察を行った。分析の結果は以下のとおり。第一に、作物の単収はエルニーニョ発生時に減少する傾向が見られるが、その影響は農家が事前に作付面積を減少させることによって大きく緩和されていることが明らかになった。特に、トウモロコシ、ジャガイモ、落花生、コメで作付面積の減少率が大きかった。

第二に、過去の市場価格や別の作物価格などが様々な形で今期の作付面積に影響を及ぼしていることが明らかになった。コメ、大豆、トウモロコシなどの主要作物では、作付面積と市場価格との間に正の関係が認められたのに対し、落花生、サツマイモ、ジャガイモではそのような関係は確認できなかった。畑作物の一部では、ジャカルタでの市場情報が農村部まで届かず、農家の作付行動に影響を与えていないことを示唆している。

畑作物の生産振興を図るためには、市場流通制度を整備し、畑作物にも価格インセンティブを付与することが重要である。また、畑作物の市場流通は食品産業やアグリビジネスへの需要に応えるためにも重要になっており、付加価値の向上にも寄与することが期待されている。

1. INTRODUCTION

Indonesia was hit hard by the Asian economic crisis of 1997. Inflation rose by over 70% and this crisis certainly brought on increased poverty in Indonesia. Unfortunately, it was not only the economic crisis but also abnormal weather that struck Indonesia. A strong El Nino occurred just after the onset of the economic crisis, leading to a further crumbling of the economy. A long dry season and a strong El Nino-induced drought led to a climatic crisis in Indonesia, resulting in a decrease in food crop production in 1998 (Irawan, 2002).

This paper analyzes rice and six secondary crops in Indonesia. These secondary crops, also known as CGPRT crops, are corn, soybeans, cassava, groundnuts, sweet potatoes and potatoes. For the last three decades the percentage share of the area in which secondary crops have been harvested in Indonesia has remained almost unchanged, nearly 40% of the total food crop area. Farmers in Indonesia have grown secondary crops in an area almost as large as that given over to rice.

Most Indonesians consume rice as their staple food. Rice supplies more than 50% of total daily calorie intake (Firdaus et al., 2008). Due to the high demand for rice compared with secondary crops, the price of rice is higher than that of other food
crops. In terms of the sales value of all food crops, the share of rice is a little less than 80%.

Despite their relatively low value compared to rice, secondary crops have recently gained more attention due to their multi-faceted roles. Secondary crops reduce the climatic risks of rain-fed agriculture, improve food security and alleviate poverty in a cost-effective manner. The processing and marketing of these crops also provides job opportunities for the poor and the landless in marginal areas (Yokoyama, 2002).

Most of the poor in Indonesia live in rural areas and many farmers in upland areas depend on secondary crops rather than rice for their income. The development of secondary crops therefore has the potential for rural poverty alleviation (Yonekura, 2006).

2. OBJECTIVES AND HYPOTHESIS

The first objective of this study is to examine whether or not, and to what extent, farmers change the amount of area harvested as a response to El Nino. Area harvested refers to the net area which includes only the portion of the gross area actually cultivated. In Indonesia, the planted area and harvested area are practically identical. Planted area data is necessary to estimate the quantities used for seeding purposes; harvested area, to provide reliable and accurate yield and production data (FAO, 2009). Secondly, the effects of price fluctuations for the area harvested are analyzed using the Area Response Model. The development of secondary crops is necessary to improve farmers’ accessibility to the market. This study analyzes how farmers change the amount of area harvested by changing commodities that are grown and harvested depending upon price fluctuations. The presence of “own price effect” (positive correlation between area harvested and price), indicates that price information is transmitted effectively to the farmers, affecting their decisions. This “own price effect” is considered as a necessary condition for inducing farmers to develop secondary crop production.

“Cross price impacts” can also be observed among different crops. “Cross price impacts” indicate that a change in the price of one commodity will affect the area harvested for other commodities. “Cross price impacts” can be either positive or negative. Farmers respond to price changes and change their cropping patterns and crop combinations through double (or triple) cropping and intercropping, though under the constraints of water availability and other inputs.

3. ANALYTICAL MODEL AND DATA

1) Impacts of El Nino on the Farm Economy

To examine the impacts of climatic shocks such as El Nino, the percentage differences in production and area harvested during El Nino years and non-El Nino years were calculated. The percent difference in yield rate can be reached using equation (1).

\[
\frac{\Delta \left( \frac{Q}{A} \right)}{\left( \frac{Q}{A} \right)} = \frac{\Delta Q}{Q} - \frac{\Delta A}{A}
\]

Q: production,  
A: area harvested

Farmers can change the area harvested to mitigate the impact of El Nino, because even small resource-poor farmers have accumulated experience and knowledge that have been handed down from generation to generation. To some extent, the significant percentage differences observed in area harvested between El Nino years and non-El Nino years indicates the presence of self-protective actions taken by farmers.
2) Area Response Model

The desired area to be allocated to a crop is a function of expected prices and a number of "shifters" (explained later). In this study, Area Response Models were estimated from time series data for rice and secondary crops using the following model specification:

\[ A_t = b_0 + b_1 A_{t-1} + \sum_{k=0}^t \sum_{i} b_{i,t-k} p^*_i,t-k + Z_t + E_t \]

- \( A_t \): area harvested
- \( b_0 \): intercept
- \( b_1 \): short-run coefficient (elasticity) of area response
- \( p^*_i \): real food crops prices (lag t or t-1)
- \( Z_t \): instrument, exogenous shifters like time and or time?, El Nino dummy
- \( E_t \): error term
- \( t \): time subscript
- \( i \): crop
- \( k \): lag of price

In time series models, it is quite possible to obtain relationships where the concept of time plays a more central role (Asteriou & D. and Hall, S.G, 2007 page 204). Area harvested of one commodity is not dependent only on the current price, but also on past (lagged) prices. Therefore, a dynamic model that can capture the effects of time paths of exogenous variables and the lagged effect is needed. In other words, this time series model assumes that farmers form their expectations for prices at harvest time on the basis of actual past prices.

A set of exogenous shifters such as weather are also needed in this model. Here, El Nino is used as an exogenous variable. Other exogenous variables are deterministic regressors such as time trends and regressors with fixed lags.

This method has certain econometric advantages; one is that the long and short-run parameters of the model are estimated simultaneously (for details see Sadoulet E and de Janvry A, 1995 page 86).

3) Data

There are four kinds of data used in this study: price, production, area harvested and dummy variables for El Nino years. For price data, Jakarta wholesale prices were used in all cases as an instrument to explain changes in producer prices (Bottema and Altemeier, 1991). Jakarta Consumer Price Index (CPI) was used as a deflator for the nominal price to get the real price.

Rice and secondary crop national production and area harvested data were obtained from FAOSTAT and United Nations ESCAP, UNCAPSA. Price data were obtained from UNCAPSA and CBS Indonesia. Since the most complete data for each crop are available from 1977 to 2006, this study uses this range of years.


4. RESULT OF ANALYSIS

1) Impacts of El Nino on the Farm Economy

The percentage difference of El Nino years compared to non-El Nino years regarding yield, production and area harvested are presented in Table 1.

El Nino had a negative impact not only on rice but also on secondary crop yields, production and area harvested. The comparison of rice and secondary crops related to El Nino was aimed at finding crops that produced better in El Nino than rice. Crops with a lower percent difference were considered to be less vulnerable to El Nino shock.

The findings in Table 1 indicate that the area harvested in El Nino years has been significantly reduced for corn, potatoes, groundnuts and rice. Table 1 also shows that corn has the highest percentage of reduction of yield rate due to water
shortages caused by El Nino. The decrease in area harvested reflects farmers’ reluctance to grow these crops in El Nino years.

Soybeans and sweet potatoes produce better than rice in El Nino years (Table 1). Increased availability of these crops in times of climatic shock could strengthen the nation’s food security. Soybeans substituted for rice in paddy fields suffered from water shortages in the rainy season during El Nino years.

Cassava can also withstand the bad weather of El Nino better than rice (Table 1). In terms of both area harvested and production, the degrees of impact on cassava were much lower than on rice. This is because cassava is highly adaptable to water shortages. Cassava thus has a role as a complementary staple food during times of rice production failures due to El Nino.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>%Difference of Yield Rate</th>
<th>%Difference of Production</th>
<th>%Difference of Area Harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>-3.23</td>
<td>-10.66</td>
<td>-7.43</td>
</tr>
<tr>
<td>Corn</td>
<td>-12.74</td>
<td>-26.76</td>
<td>-14.02</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-2.41</td>
<td>6.70</td>
<td>9.12</td>
</tr>
<tr>
<td>Cassava</td>
<td>-8.19</td>
<td>-8.88</td>
<td>-0.68</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>-5.64</td>
<td>-13.70</td>
<td>-8.06</td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>-4.11</td>
<td>-1.88</td>
<td>2.22</td>
</tr>
<tr>
<td>Potatoes</td>
<td>-3.70</td>
<td>-26.62</td>
<td>-22.92</td>
</tr>
</tbody>
</table>

Source: Author’s calculation.

Potatoes showed the largest decrease in area harvested. Due to the potato’s characteristic of only growing well in a cool environment, farmers avoid growing potatoes in long dry seasons caused by El Nino.

Improvement of the production stability of corn, groundnuts and potatoes is critical. Crop diversification by growing cassava, sweet potatoes and soybeans in El Nino years may improve the stability of food production in times of climatic shock.

2) Area Response Model

Table 2 shows the estimated results of the Area Response Model for rice and secondary crops in Indonesia.

Exogenous variables included are time, time squared and El Nino. Overall, R-squared statistics are high, and Durbin-Watson statistics are in a reasonable range. Schwartz Bayesian Criteria (SBC) is used to find the desirable length of lag.

Estimated results in Table 2 demonstrate short-run relationships between area harvested and price. For example, the area harvested for rice is affected by both rice and corn prices. Note that not only the present price but also the lagged prices of these crops affect the area harvested of rice. As for the rice price, the lagged price (LRIP (-1)) has a bigger impact on rice area harvested than the present year’s price (LRIP). In contrast, the corn lagged price (LCORP (-1)) has less impact on area harvested of rice than the current price (LCORP). Thus, area harvested for rice has its “own price effect” and “cross price impact” on corn, but dynamic impacts through price changes on area harvested are different and related to time.

The area harvested in previous years affected the current year’s area harvested for soybeans and sweet potatoes (shown by LAH (-1) in Table 2). For other commodities, the area harvested in previous years has not affected the area harvested of the current year.
Table 2. Estimation results of area response model for rice and secondary crops in Indonesia

<table>
<thead>
<tr>
<th></th>
<th>RICE (LAH(-1))</th>
<th>CORN (LRIRP)</th>
<th>SOYBEANS (LRIRP(-1))</th>
<th>CASSAVA (LCORP)</th>
<th>GROUNDNUTS (LCORP(-1))</th>
<th>SWEET POTATOES (LSORP)</th>
<th>POTATOES (LSORP(-1))</th>
<th>Intercept (LPORP)</th>
<th>TIME2 (LPORP(-1))</th>
<th>D(El Nino) (LPERP)</th>
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<tr>
<td></td>
<td>0.664***</td>
<td>0.083**</td>
<td>0.130***</td>
<td>-0.104***</td>
<td>0.413***</td>
<td>-0.182*</td>
<td>-0.390*</td>
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<td>0.216***</td>
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<td>-0.031***</td>
<td>-0.130**</td>
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</table>

Note: ***Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level.

The ARDL method can simultaneously estimate long and short-run parameters. Long run estimates can be calculated from the estimation results in Table 2. For example, the long-run estimate for LRIRP (log of rice price) is 0.213 (Table 3). This is a sum of the coefficients for LRIRP (0.083) and LRIRP (-1) (0.130), which are shown in Table 2. Another example for soybean area harvested, in the long-run estimation, -1.264 (coefficient of LCORP), comes from -0.424 (coefficient of LCORP in short run) divided by (1-0.664) since the area harvested for soybeans is affected by the area harvested in previous years with the coefficient of 0.664 (see Table 2).

Table 3 summarizes the long-run estimates of the area harvested for rice and secondary crops in Indonesia. It shows that rice, corn and soybeans have their "own price effect" at 1% significance level. Other crops show no significant "own price effect". All crops have "cross price impacts". The results show no reversible effects; for example the corn price affects rice area harvested but the rice
price does not affect corn area harvested. Crops with multiple functions (food consumption and industrial consumption, for example) may have a larger impact on other crops.

5. DISCUSSION

1) Secondary Crops and Price Response

Food crops can be categorized into two groups depending upon whether or not the crop has its "own price effect" (see Table 3).

Crops in the first category are rice, corn, soybeans and cassava. Rice, as a staple food, has brought farmers' attention to price change and causes them to respond sensitively toward area harvested. Corn, soybeans and cassava are three major secondary crops in terms of area harvested. Since the distribution system for major secondary crops has been developed, it has allowed farmers to respond to changes in price.

Crops that have no "own price effect" are included in the second group. Those crops are groundnuts, sweet potatoes and potatoes. Estimated results also indicate that market information is not transmitted well to the farmers, generating no price incentive. These findings imply that the distribution system has not developed well for these minor secondary crops.

Sweet potatoes yield during the last decade has been stagnant at 9-10 tonnes/ha. Factors that have caused low sweet potato productivity are: (1) low and fluctuating root crop prices at the production level because of the marketing system (about 30 percent was spent on transportation costs); (2) the local market for sweet potatoes is still undeveloped; and (3) post-harvest technologies have not been adopted by farmers (CBS, 2000).

Indonesia has so far failed to capitalize on Asia's growing processed potato market, especially for French fries and potato chips. Farmers remain reluctant to grow potatoes because selling prices are prone to large fluctuations. On average, potato growers earned between Rp 15 million and 20 million per hectare. In the past four years, potato prices have fluctuated between Rp 2,000 and Rp 5,000 per kilogram (The Jakarta Post, 22 May 2008). Thus, the development of a nexus between local and central markets, particularly the Jakarta market for minor secondary crops is needed to stabilize price volatilities. Furthermore, the development of market efficiency through efficient transportation in agri-business and the food industry needs to be included in the agenda to increase value-added for minor secondary crops.

<table>
<thead>
<tr>
<th>Table 3. Long run estimates of the area harvested of rice and secondary crops in Indonesia</th>
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<tbody>
<tr>
<td>RICE</td>
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<tr>
<td>------</td>
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<tr>
<td>LRIRP</td>
</tr>
<tr>
<td>LCORP</td>
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<tr>
<td>LSORP</td>
</tr>
<tr>
<td>LCARP</td>
</tr>
<tr>
<td>LPERP</td>
</tr>
<tr>
<td>LPORP</td>
</tr>
<tr>
<td>D (EI Nino)</td>
</tr>
</tbody>
</table>

Note: ***Significant at the 1 percent level; **significant at the 5 percent level; *significant at the 10 percent level.

LRIRP : Log of rice real price
LCORP : Log of corn real price
LSORP : Log of soybeans real price
LCARP : Log of cassava real price
LPERP : Log of groundnuts real price
LPORP : Log of potatoes real price
LSWRP : Log of sweet potatoes real price
2) Crop Selection, Cropping Patterns, and Price Response

Finally, traditional cropping patterns in Indonesia, particularly in Java where most food crops are produced, are shown in Figure 3. There are three planting seasons in Indonesia. Generally farmers can grow rice twice a year, but their decisions are affected by changes in climate and relative price. They also try to mitigate the impact of El Nino by selecting crops according to water availability.

While “own price effect” represents the level of market development, “cross price impacts” indicate farmers’ strategic behavior regarding intercropping and double cropping which are adopted to maintain or increase income while mitigating various risks.

Positive “cross price impacts” were found between cassava-corn and cassava-soybeans (Table 3). The intercropping system is applied in Indonesia (Sullivan, 2003 page 5). In Indonesian language (Bahasa Indonesia) this is called Tumpang Sari. Farmers can grow more than one commodity in the same plot, in the same area, and in one season. Diversifying corn farming by intercropping with cassava has increased the cassava area harvested during corn growing seasons.

Negative “cross price impacts” lead to crop selection. Relative price change has offered alternatives to farmers and has affected their decision to select certain crops. For example, a combination of rice and corn is a typical pattern in Indonesia. Cropping patterns such as a negative “cross price impact” of rice with corn are found. Some possible alternatives based on Table 3 are: 1) Rice or Cassava, 2) Soybeans or Corn, 3) Corn or Groundnuts or Potatoes, 4) Groundnuts or Potatoes and 5) Sweet Potatoes or Cassava or Potatoes.

6. CONCLUSIONS

Reduced rainfall because of El Nino threatens human food security by its impact on water and food supplies. Farmers have the capability to reduce the negative impacts of climatic shock by growing more resistant crops. In the case of El Nino, the capability of farmers through a harvested area response was observed as they turned to such crops as cassava, sweet potatoes and soybeans. Cassava with its high adaptability for drought can play a role as a complementary staple food in times of rice
production failure. The growing of sweet potatoes and soybeans improves the stability of food crop production in times of climatic shock and could strengthen the nation’s food security.

Farmers can cope with price changes by selecting crops based on price information and diversifying production by changing cropping patterns.

ACKNOWLEDGEMENT

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REFERENCES