## Regional Rice Initiative (RRI) Policy Simulation to Alleviate Climate Risks of Rice Production System and Rice Market

### FINAL TECHNICAL REPORT

## I. Background

The FAO-supported Regional Rice Initiative (RRI) Project started in May 2013 and its overall objective is to (i) promote the importance of goods/services produced by and available from rice ecosystems and (ii) identify sustainable rice production practices to improve food security. The participating countries for the RRI project are the Philippines, Laos and Indonesia.

The RRI has four different Components:

1. ***Component 1*** – conduct assessments of ecosystem services produced by fisheries and aquaculture within rice-field production systems, and improve water management practices that are able to take into account the changing irrigation and drainage services required by farmers for the adoption of sustainable management practices in dynamic economic and water resources settings.

2. ***Component 2*** - build knowledge and capacity in the form of tools, training and analysis for integrated management of biodiversity, landscapes and ecosystem services to enhance sustainability in rice ecosystems, including studies of "Trees outside Forests", or trees in rice fields.

3. ***Component 3*** – focus on capacity building of famers adopting and practicing "Save and Grow" and sustainable intensification of rice production through Farmer Field Schools (FFS).

4. ***Component 4*** – develop information and knowledge products for policy makers to better manage climate risks in the rice sector and to identify adaptation needs for the rice sector with support from the AMICAF (Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security) project. This component also promotes understanding and awareness of the importance of paddy ecosystems, associated knowledge systems, biodiversity, landscapes and cultures through the Globally Important Agricultural Heritage Systems (GIAHS) Initiative.

The NEDA is a partner agency under Component 4. The NEDA component started in 17 September 2013 and was completed on 31 December 2014.

## II. Project Objectives

The NEDA component under the RRI Project aims to conduct a policy simulation on the impact of climate change on the Philippine rice market using the Provincial Agricultural Market (PAM) Model developed under the AMICAF Project.

## III. Methodology

### A. Overall Methodology

Similar to the approach under the AMICAF project, the impact (e.g. elasticity) of the policy variable to rice yield was estimated first by using a ***separate*** regression model. Afterwards, the percentage change in yield due to the impact of the policy variable is inputted to the PAM model (i.e. treated exogenously) to conduct the policy simulation. The level of public expenditure on agriculture was considered as the policy variable since a long time-series data is already available at Bureau of Agricultural Statistics of the Philippine Statistical Authority (PSA-BAS).

### B. Development of Regression Model

#### 1. *Overview of Regression Model*

a. The regression model was estimated with two (2) behavioural equations[1] and one (1) identity equation[2].

b. The model parameters were estimated using Ordinary Least Squares (OLS) Regression on 1981-2010 time series data from PSA-BAS (for rice data) and PAGASA (for climate variables).

c. The estimated parameters provide the impact of government agriculture expenditure, maximum temperature, minimum temperature and precipitation on rice yield by ecosystem for 1981-2010.

d. The regression model was used to make a projection of future irrigated rice yield up to year 2030 assuming that the government agriculture expenditure will increase by 5% annually in 2011-2030.

e. The percentage change in future irrigated rice yield was inputted in the PAM model to conduct the policy simulation under this study.

#### 2. *Description of Variables Used*

The list of data, source and name of variables used in the development of the regression model is presented in ***Table 1*** below. The policy variable used is the level of government expenditure on agriculture expressed as a ratio versus the total government expenditure. The time series data on government expenditure on agriculture was sourced from the PSA-BAS[3]. The climate variables used on maximum temperature, minimum temperature and precipitation were sourced from the projection of PAGASA under the AMICAF Project.

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[1] A behavioural equation is an equation that was estimated from historical data and contains an error term which accounts for the effect of other factors not included in the equation.

[2] An identity equation refers to an equation that is true by definition.

[3] There is no long time-series data on public expenditure on rice only covering 1981-2010. The simulation under this study assumes that a large portion of public expenditure on agriculture has been devoted to rice.

**Table 1. List of Data and Name of Variable Used**

| Variable | Description | Source |
|---|---|---|
| yieldir (mt/ha) | Yield of irrigated palay | Computed from BAS data |
| yieldra (mt/ha) | Yield of rainfed palay | |
| yieldt (mt/ha) | Yield of palay (all ecosystem) | |
| agriexpr (Php) | Ratio of govt. agri expenditure to total expenditure | |
| fprice (Php/kilo) | Farmgate price of palay | BAS |
| weightir | Share of irrigated palay based on area harvested | Computed from BAS data |
| weightra | Share of rainfed palay based on area harvested | |
| tmax (degree C) | Maximum Temperature | Projections by PAGASA w/ bias correction by FAO |
| tmin (degree C) | Minimum Temperature | |
| Precip (mm) | Precipitation | |

Source: NEDA-ANRES

3. ***Specification of the Regression Model***

There are separate equations for irrigated and rainfed yield since the impact of climate variables may differ by ecosystem as follow:

Equation 1 is the irrigated yield equation as a function of the ratio of government expenditure on agriculture versus its total expenditure, farmgate price lagged by one (1) year, maximum temperature, minimum temperature and *u* is the error term.

**Equation 1:**

$$dlog(yieldir) = \alpha + \beta_1 * dlog(agriexpr) + \beta_2 * dlog(fprice(-1)) - \beta_3 * dlog(tmax) - \beta_4 * dlog(tmin) + u$$

Equation 2 is the rainfed yield equation as a function of farmgate price lagged by one (1) year, precipitation, maximum temperature and minimum temperature and *v* is the error term.

**Equation 2:**

$$dlog(yieldra) = \alpha + \beta_1 * dlog(fprice(-1)) + \beta_2 * dlog(precip) - \beta_3 * dlog(tmax) - \beta_4 * dlog(tmin) + v$$

According to a draft study by *Habito et al in 2011 entitled Fostering our Farms, Fisheries and Food*, about 60%-70% of the DA's budget was spent on rice.

Equation 3 computes for the total yield and it is the weighted average of irrigated and rainfed yield from Equation 1 and Equation 2, respectively, with the weights computed based on area harvested.

**Equation 3**: $$yieldt \equiv yieldir * weightir + yieldra * weightra$$

The hypothesis is that ***tmax*** and ***tmin*** have a negative impact on both irrigated and rainfed yield, while precipitation has a positive impact on rainfed yield[4]. The term ***"dlog"*** means the difference in logarithm of the variables which is equivalent to expressing them in growth rates. The variables were expressed in difference in logarithm to address the issue of non-stationarity[5].

4. ***Estimated Regression Model***

Two (2) regression models were estimated: (i) Model 1 wherein some of the variables are ***log*** transformed[6] with a time trend, and (ii) Model 2 wherein all variables were expressed in growth rates as specified in Section III Item 3. It was necessary to estimate Model 1 since the Adjusted $R^2$ of Model 2 is low for the purpose of conducting a projection (***Table 2***). The Adjusted $R^2$ of Model 1 is 0.92 which means the identified variables can explain 92% of the variation in irrigated and rainfed yield. Moreover, there is no significant change in the magnitude of the coefficient of ***agriexpr*** (the policy variable) in either model. Thus, Model 1 was used in the conduct of the simulation. The parameters of the regression model were estimated using EViews 7.2 software.

**Table 2. Estimated Parameters of the Regression Model**

| Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|
| **Variable** | **In Log Level w/ Trend** | | **Variable** | **In Log Difference** | |
| | log (yieldir) | log (yieldra) | | dlog (yieldir) | dlog (yieldra) |
| Intercept | 2.580*** | 1.745 | Intercept | 0.012** | 0.019** |
| log(agriexpr) | 0.070** | | dlog(agriexpr) | 0.069** | |
| tmax | -0.041* | | dlog(tmax) | -1.205** | |
| precip | | 0.00005** | dlog(precip) | | 0.142*** |
| tmin | | -0.061 | dlog(tmin) | | -1.274 |
| trend | 0.010*** | 0.018*** | | | |
| AR(1) | 0.734*** | 0.767*** | | | |
| n | 30 | | n | 30 | |
| Adjusted $R^2$ | 0.92 | 0.92 | Adjusted $R^2$ | 0.32 | 0.22 |
| Note: (1) Parameters were estimated using OLS Regression with AR term | | | | | |
| (2) ***significant at 1% level; ** 5% level; * 10% level | | | | | |

Source: NEDA-ANRES estimate

[4] In a study by *Sarker, Alam and Gow in 2012 entitled Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data and published in Agricultural Systems*, they found a statistically significant positive relationship between rainfall and rice yield in 2 out of 3 models.
[5] Non-stationary data means their variance and covariance changes over time. All of the variables used, except precipitation, are found to be non-stationary under this study by using the Augmented Dickey Fuller (ADF) Test and Phillips-Perron (PP) Test.
[6] The natural logarithm of the values of the variables.

The ratio of government agriculture expenditure vs. total (***agriexpr***) was found to be statistically significant at the 5% level (**Table 2**). The estimated elasticity of ***agriexpr*** is about 0.07 which means that a 1% increase in ***agriexpr*** will lead to a 0.07% increase in irrigated yield. Both maximum and minimum temperature have a negative impact on both irrigated and rainfed palay yield. However, only maximum temperature is statistically significant. Precipitation has a small positive impact on rainfed yield and is statistically significant at the 5% level.

5. ***Diagnostic Tests***

Basic diagnostic tests also indicate that the regression model satisfies the tests on normality of residual[7], serial correlation[8], and heteroskedasticity[9] at the 5% level (***Table 3***). However, there is presence of multicollinearity[10] under Model 1 based on the Variance Inflation Factor (VIF)[11]. Although there is multicollinearity, it does not affect the unbiasedness[12] of the estimated parameters in the model. Moreover, Model 1 can make reasonable forecast since the bias and variance proportions of the reported Theil Coefficient are smaller compared to the covariance proportion.

**Table 3. Results of Common Diagnostic Test for Regression**

| Item | Test/Criteria | Model 1 In Log Level w/ Trend | | Model 2 In Log Difference | |
|---|---|---|---|---|---|
| 1) Normality of Residual | Jarque-Bera | 0.59 (p-value) | 0.75 (p-value) | 0.68 (p-value) | 0.71 (p-value) |
| 2) Serial Correlation | Breusch-Godfrey | 0.35 (p-value) | 0.61 (p-value) | 0.82 (p-value) | 0.64 (p-value) |
| 3) Heteroskedasticity | Breusch-Pagan-Godfrey | 0.33 (p-value) | 0.07 (p-value) | 0.73 (p-value) | 0.27 (p-value) |
| 4) Multicollinearity | Variance Inflation Factor | yes for tmax (uncentered VIF) | yes for tmin (uncentered VIF) | none (VIF is less than 10) | none (VIF is less than 10) |
| 5) Theil Coefficient | Bias Proportion | 0.02 | 0.00 | 0.39 | 0.00 |
| | Variance Proportion | 0.21 | 0.06 | 0.00 | 0.06 |
| | Covariance Proportion | 0.77 | 0.94 | 0.60 | 0.94 |

Source: NEDA-ANRES

C. **Development of the Provincial Agricultural Market (PAM) Model**

Under the AMICAF Project, a partial equilibrium[13] econometric model was developed in partnership with the FAO[14] called the “Provincial Agricultural Market” model or PAM. The following are the major features of PAM model:

- *Uses Microsoft Excel as platform* – The MS Excel is common software and less complicated to operate compared to other statistical software (e.g. EViews, Stata, GAMS).

[7] The residual is normally distributed
[8] The error term is related to itself in time
[9] The variance is not constant
[10] An independent variable is related to other independent variables in the model which makes it hard to estimate their separate effects.
[11] A VIF of more than 10 indicates the presence of multicollinearity.
[12] Unbiasedness means that the estimated coefficients are equal to the true population parameters on average.
[13] A partial equilibrium model focuses on one or more sectors of the economy and assumes that changes in other sectors are negligible.
[14] The PAM was developed by Dr.Tatsuji Koizumi of the FAO.

- *Commodity coverage* – The focus commodity is irrigated rice and rainfed rice.

- *Spatial coverage* – The model is disaggregated by province.

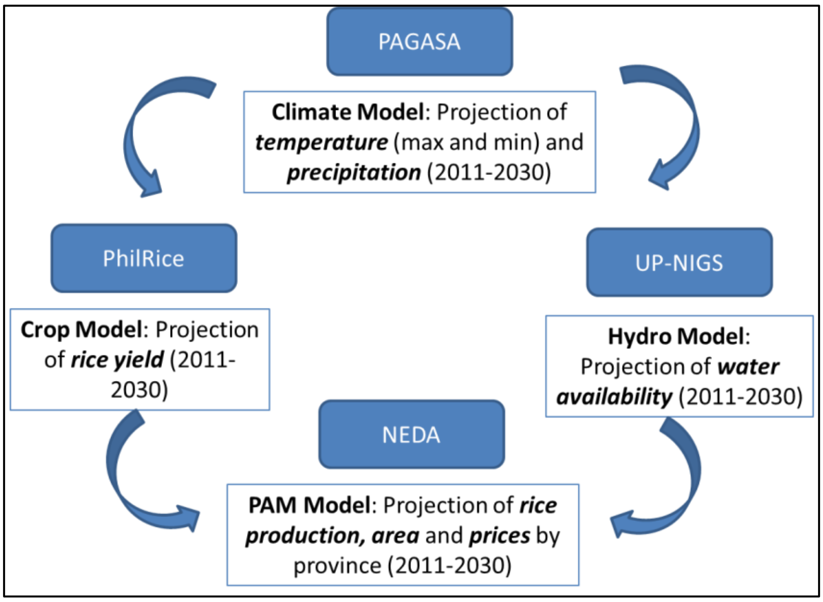
- *Timeframe of projection* – From year 2011 to year 2030.

- *Major variables in projection* – Irrigated rice production, rainfed rice production, irrigated rice area harvested, rainfed rice area harvested and farmgateprices.

1. **Linkage of the PAM Model with other Step 1 AMICAF Models**

The PAM model is not a stand-alone model, but is linked with other models of other partner agencies under Step 1 of the AMICAF Project (Figure 1). This partnership between different agencies and linkage between various models enables a multi-disciplinary approach in assessing the different impacts of Climate Change.

**Figure 1. Linkage of the PAM Model with other Step 1 Models**




Source: NEDA-ANRES

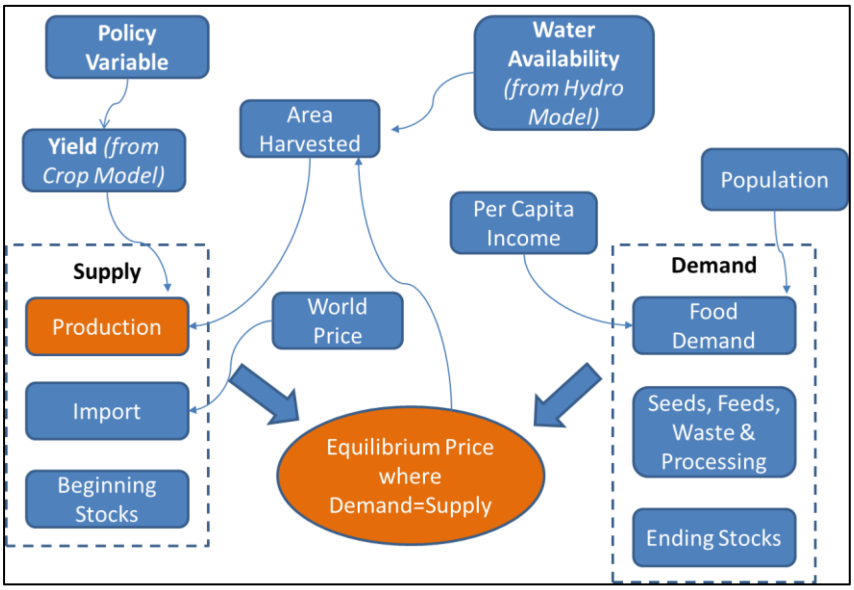
First, the PAGASA conducted a downscaling of the projected minimum temperature, maximum temperature and precipitation of three (3) Global Circulation Models (GCM) namely: (i) Bergen Climate Model (BCM) from Norway, (ii) Centre National de Recherches Meteorologiques (CNCM3) from France, and (iii) Max-Planck-Institute for Meteorology (MPEH5) from Germany. Two (2) climate change scenarios were used by each GCM: (i) A1B Scenario and (ii) A2 Scenario. The A1B Scenario is a medium-range emission scenario characterized by a balance in the use of both fossil and non-fossil fuel, while the A2 Scenario is a high-range emission scenario focused on regionally-oriented economic development in the future. The emission scenarios are based on the Special Report on Emissions Scenarios (SRES) by the Intergovernmental Panel on Climate Change (IPCC) published in 2000. These projections of climate variables were then used by the PhilRice to conduct a projection of future irrigated and rainfed rice yield, and by the UP-NIGS to conduct a projection of future water discharge (or availability) in major river basins in the Philippines from 2011 to 2030.

The projections of PhilRice on rice yield and UP-NIGS on water discharge are integral inputs to the PAM Model under the NEDA component. The projected yields and water discharges are used in the computation of area harvested and total rice production to come up with projected rice prices in 2011-2030.

## 2. Framework of the PAM Model with Policy Variable

The PAM model computes an equilibrium price (farmgate) that balances the supply and demand of rice in the market (Figure 2). The supply of rice is composed of domestic production, import and beginning stocks. The demand for rice, on the other hand, is composed of food demand, demand for seeds, feeds, waste and processing as well as ending stocks.

**Figure 2. Framework of the PAM Model with Policy Variable**




Source: NEDA-ANRES

An increase in the supply of rice relative to demand, will lead to a decrease in prices, while an increase in the demand of rice relative to supply, will lead to an increase in prices[15]. The policy variable such as public expenditure on agriculture affects yield which in turn will affect domestic rice production.

The most important component of rice supply is domestic production. It is computed as the product between the yield projections from the Crop Model of PhilRice and area harvested. The area harvested in the PAM model is affected by water availability from the projection of UP-NIGS. On the other hand, the bulk of rice demand comes from food demand which in turn is affected by per capita income and population growth.

## 3. Major Equations of the PAM Model

*a.* ***Equation for Irrigated Rice Production***. Irrigated palay production is computed, by province, as the product between irrigated yield and area harvested. It is converted to milled terms by using the standard conversion factor of 0.654.

[15]with the assumption of ceteris paribus or all else equal.

$$Irrigated\ Production = Irrigated\ Yield * Area\ Harvested \quad (1.1)$$

b. ***Equation for Irrigated Area Harvested.*** Irrigated area harvested is computed as a function of farmgate price. The magnitude of the change depends on the value of the elasticity of irrigated area harvested with respect to rice price. The elasticity is a positive number and it varies in each province which was estimated by using Ordinary Least Squares (OLS) Regression.

$$Irrigated\ Area\ Harvested = Area\ Harvested_{t-1} * \left(\frac{farmgate\ price_t}{farmgate\ price_{t-1}}\right)^{\wedge rice\ price\ elasticity} \quad (1.2)$$

c. ***Equation for Rainfed Rice Production****.* Rainfed palay production is computed, by province, as the product between rainfed yield and area harvested. It is converted to milled terms by using the standard conversion factor of 0.654.

$$Rainfed\ Production = Rainfed\ Yield * Area\ Harvested \quad (1.3)$$

d. ***Equation for Rainfed Area Harvested.*** Rainfed area harvested is computed as a function of farmgate price and corn price. The magnitude of the change depends on the value of the elasticity of rainfed area harvested with respect to rice price and corn price. The elasticities vary in each province and were estimated using Ordinary Least Squares (OLS) Regression.

$$Rainfed\ Area\ Harvested = Area\ Harvested_{t-1} * \left(\left(\frac{farmgate\ price_t}{farmgate\ price_{t-1}}\right)^{\wedge rice\ price\ elasticity} * \left(\frac{corn\ price_t}{corn\ price_{t-1}}\right)^{\wedge corn\ price\ elasticity}\right) \quad (1.4)$$

e. ***Equation for per capita consumption.*** The per capita consumption (PCC) for rice is computed as a function of per capita Gross Domestic Product (GDP), rice retail price and corn retail price (substitute commodity). The income elasticity used is 0.23, rice price elasticity is -0.24 and corn price elasticity is 0.15. The PCC is computed at the national level.

$$PCC = PCC_{t-1} * \left(\left(\frac{pc\ GDP_t}{pc\ GDP_{t-1}}\right)^{\wedge(0.23) income\ elasticity} * \left(\frac{rice\ retail\ price_t}{rice\ retail\ price_{t-1}}\right)^{\wedge(-0.24) rice\ price\ elasticity} * \left(\frac{corn\ retail\ price_t}{corn\ retail\ price_{t-1}}\right)^{\wedge(0.15) corn\ price\ elasticity}\right) \quad (1.5)$$

f. ***Equation for food consumption.*** The total food consumption or demand is computed as a product between PCC and population. The total food consumption is computed at the national level.

$$Food\ Consumption = PCC * Population \quad (1.6)$$

g. ***Equation for imports.*** The level of imports is computed as a function of the wholesale price of rice and the world price of rice. The world price of rice is an exogenous variable taken from the Rice Economy Climate Change (RECC) Model[16]. The RECC Model is an international model covering rice markets in 15 countries and generates world price projections under Climate Change. The rice price elasticity used is -0.10 and the world price elasticity is -0.44. This means that increases in the wholesale and world prices for rice will lead to a decline in the level of imports. The level of imports is computed at the national level.

$$Imports = Imports_{t-1} * \left(\left(\frac{wholesale\ price_t}{wholesale\ price_{t-1}}\right)^{(\wedge -0.10) rice\ price\ elasticity} * \left(\frac{world\ price_t}{world\ price_{t-1}}\right)^{\wedge(-0.44) world\ price\ elasticity}\right) \quad (1.7)$$

h. ***Equation for ending stocks.*** The ending stock of rice is a function of rice consumption. The magnitude of change depends on the value of the elasticity of ending stocks with respect to rice food consumption. The elasticity used is -0.05 which means that an increase in rice food consumption will lead to a decrease in ending stocks for rice.

$$Ending\ Stocks = Ending\ Stocks_{t-1} * \left(\left(\frac{rice\ food\ consumption_t}{rice\ food\ consumption_{t-1}}\right)^{\wedge(-0.05) rice\ consumption\ elasticity}\right) \quad (1.8)$$

i. ***Equation for wholesale price.*** The wholesale price of rice is computed as a function of farmgate price. The magnitude of change depends on the value of the elasticity of wholesale price with respect to farmgate price. The elasticity used is 0.92 and was estimated using OLS Regression.

$$Wholesale\ Price = Wholesale\ Price_{t-1} * \left(\left(\frac{Farmgate\ Price_t}{Farmgate\ Price_{t-1}}\right)^{\wedge(0.92)\ rice\ price\ elasticity}\right) \quad (1.9)$$

j. ***Equation for retail price.*** The retail price of rice is computed as a function of farmgate price. The magnitude of change depends on the value of the elasticity of retail price with respect to farmgate price. The elasticity used is 0.99 and was estimated using OLS Regression.

$$Retail\ Price = Retail\ Price_{t-1} * \left(\left(\frac{Farmgate\ Price_t}{Farmgate\ Price_{t-1}}\right)^{\wedge(0.99) rice\ price\ elasticity}\right) \quad (1.10)$$

[16] The RECC was developed by Dr.Tatsuji Koizumi of the FAO

k. ***Equation for farmgate price.*** The farmgate price is computed as the price level that balances the supply and demand of rice in the market. This equilibrium farmgate price is computed in the PAM using the Gauss-Seidel Algorithm by balancing the following equation.

$$Production + Imports + Beg.Stocks = Food\ Consumption + Seeds, etc. + End\ Stocks \quad (1.11)$$

4. **Data Used**

a. **GDP** – NEDA (2014: 6.5%, 2015: 7.0%, 2016: 7.5%) and ADB (2017-2030: 5.6%) projections[17].

b. **Population** – PSA-NSCB (2011-2020: 1.8%) and ADB (2021-2030: 1.4%) projections[18].

c. **World price of rice** – Projection of the *Rice Economy Climate Change (RECC) Model*. The RECC Model is an international partial equilibrium model covering rice markets in 15 countries and generates world price projections under Climate Change.

d. **White corn prices** – Historical farmgate price from PSA-BAS. The projection in 2011-2030 was computed by using exponential smoothing method (additive) with the root mean square error (RMSE) as criteria.

e. **Per capita consumption** – 2008-2009 Survey on Food Demand (SFD) by PSA-BAS

f. **Irrigated and Rainfed Rice Yield** – Projection from the PhilRiceCrop Model

g. **Water Availability** – Projection from the UP-NIGS Hydrology Model

h. **Baseline data** – Baseline data on rice production, area harvested, prices, imports, stocks and utilization for seeds, feeds & waste, and processing from PSA-BAS.

[17] Asian Development Bank, 2011. Long-Term Projection of Asian GDP and Trade.
[18] Ibid

## IV. Results and Discussion

1. **Assumptions by Scenario**. The policy simulation using the PAM model was conducted by assuming that irrigated yield will increase by 1.85% on the average due to a 5% annual increase in government agriculture expenditure in 2011-2030 (***Table 4***). The future increase in irrigated yield was projected using the regression model (Section III, Item B) with an estimated elasticity of irrigated rice yield with respect to the ratio of government agriculture expenditure vs. total expenditure of 0.07.

**Table 4. Assumptions by Scenario for all GCM's and Climate Scenarios**

| Item | Assumption |
|---|---|
| **Yield** *(in MT per hectare)* | **Base:** Irrigated rice yield from PhilRice with Climate Change<br><br>**Scenario:** 1.85% increase in irrigated rice yield due to 5% annual increase in government agriculture expenditure in 2011-2030 (projection using the regression model in Section III, Item B). |

Source: Irrigated yield from PhilRice under AMICAF Project

2. **Increasing the annual government expenditure on agriculture will increase domestic rice production**. Based on the average of the 3 GCMs, increasing government expenditure on agriculture by 5% annually in 2011-2030 will increase rice production from 18.23 MMT to 18.32 MMT or an increase of 0.49% under the A1B scenario (***Table 5***). The same trend is also observed under the A2 scenario. It should be noted that the increase in rice production is small since the estimated elasticity is also small at 0.07. This is included as a limitation of this study.

**Table 5. Policy Simulation on Rice Production using PAM, 2011-2030**

| Global Circulation Models | PAM Model Policy Simulation (2011-2030) | | | |
|---|---|---|---|---|
| | A1B Scenario | | A2 Scenario | |
| | 2026-2030 | 2011-2030 | 2026-2030 | 2011-2030 |
| **BCM2** | | | | |
| **Base** | | | | |
| *Production* | 20,051,810 | **18,219,269** | 20,149,405 | **18,271,459** |
| **Scenario** | | | | |
| *Production* | 20,146,331 | **18,308,724** | 20,244,783 | **18,361,297** |
| **CNCM3** | | | | |
| **Base** | | | | |
| *Production* | 20,092,749 | **18,193,216** | 20,256,070 | **18,261,476** |
| **Scenario** | | | | |
| *Production* | 20,187,083 | **18,282,047** | 20,352,393 | **18,350,890** |
| **MPEH5** | | | | |
| **Base** | | | | |
| *Production* | 20,171,416 | **18,278,796** | 20,147,284 | **18,214,459** |
| **Scenario** | | | | |
| *Production* | 20,265,898 | **18,368,527** | 20,242,956 | **18,304,274** |
| **Average of 3 GCMs** | | | | |
| Base | **20,105,325** | **18,230,427** | **20,184,253** | **18,249,131** |
| Scenario | **20,199,771** | **18,319,766** | **20,280,044** | **18,338,820** |
| % change | **0.47** | **0.49** | **0.47** | **0.49** |

Source: NEDA-ANRES estimate

3. **The increase in domestic rice production will lower farmgate prices by reducing the demand-supply deficit**. Based on the average of the 3 GCMs, increasing government expenditure on agriculture by 5% annually in 2011-2030 will lower farmgate prices from Php 23.27 per kilo to Php 22.79 per kilo or a decrease of -2.06% under A1B scenario (***Table 6***). The result is almost similar under the A2 scenario with farmgate prices projected to decrease by -2.07% on the average in the same period. This is due to higher rice production as a result of an increase in government expenditure on agriculture, which will lead to a lower demand-supply deficit and eventually lower farmgate prices.

**Table 6. Policy Simulation on Rice Farmgate Price using PAM, 2011-2030**

| Global Circulation Models | PAM Model Policy Simulation (2011-2030) | | | |
|---|---|---|---|---|
| | A1B Scenario | | A2 Scenario | |
| | 2026-2030 | 2011-2030 | 2026-2030 | 2011-2030 |
| **BCM2** | | | | |
| **Base** | | | | |
| *Farmgate Price* | 30.199 | **23.342** | 29.573 | **23.062** |
| **Scenario** | | | | |
| *Farmgate Price* | 29.583 | **22.859** | 28.968 | **22.585** |
| **CNCM3** | | | | |
| **Base** | | | | |
| *Farmgate Price* | 29.927 | **23.484** | 28.927 | **23.068** |
| **Scenario** | | | | |
| *Farmgate Price* | 29.319 | **23.001** | 28.332 | **22.592** |
| **MPEH5** | | | | |
| **Base** | | | | |
| *Farmgate Price* | 29.430 | **22.980** | 29.594 | **23.317** |
| **Scenario** | | | | |
| *Farmgate Price* | 28.834 | **22.505** | 28.986 | **22.833** |
| **Average of 3 GCMs** | | | | |
| Base | **29.852** | **23.268** | **29.365** | **23.149** |
| Scenario | **29.245** | **22.788** | **28.762** | **22.670** |
| % change | **-2.03** | **-2.06** | **-2.05** | **-2.07** |

Source: NEDA-ANRES estimate

## V. Limitation and Future Study

1. **The impact of the policy variable on rice yield is exogenous from another model.** The elasticity of irrigated yield with respect to government expenditure on agriculture was estimated from a separate model since the PAM has no built-in policy variable. This raises the issue if the analysis is done under a consistent framework.

2. **The estimated elasticity used in the policy simulation is small.** The magnitude of the estimated elasticity of irrigated yield with respect to government expenditure on agriculture of 0.07 is quite small based on the regression model using 1981-2010 time series data. Using panel data may result to a better estimate but this study is constrained by time and lack of disaggregated public expenditure data on agriculture at the provincial level to conduct such analysis.

## VI. Conclusion and Recommendation

1. **Government intervention is important to address the negative impact of climate change on future rice production and farmgate prices**. The policy simulation shows that increasing the expenditure of the government on agriculture can increase rice production in 2011-2030 (by 0.49%) which will contribute in lowering the demand-supply deficit and thereby lowering future farmgate prices (by -2.1%). Lower farmgate prices will also lead to lower retail prices and will benefit rice consumers especially the poor who spent 20% of their total food expenditure on rice.

2. **The results of the policy simulation can be further improved by incorporating policy variables directly to the PAM model and using other methods to estimate the historical impact of such policy variables.** This will ensure that the policy simulation is done under a more consistent framework. Using other methods, such as regression using panel data, may yield more robust estimates of the impact of policy variables on rice yield which will further enhance the results of the simulation.

**Annex A. Policy Simulation on Rice Production, 2011-2030**

| Global Circulation Models | PAM Model Policy Simulation (2011-2030) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1B Scenario | | | | | A2 Scenario | | | | |
| | 2011-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2011-2030 | 2011-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2011-2030 |
| **BCM2** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Production* | **16,340,409** | **17,710,475** | **18,774,381** | 20,051,810 | **18,219,269** | 16,415,214 | 17,723,432 | 18,797,783 | 20,149,405 | **18,271,459** |
| Irrigated | 12,239,967 | 13,310,799 | 14,012,587 | 14,906,859 | **13,617,553** | 12,339,515 | 13,271,240 | 13,977,551 | 15,007,748 | **13,649,014** |
| Rainfed | 4,100,441 | 4,399,676 | 4,761,794 | 5,144,951 | **4,601,715** | 4,075,699 | 4,452,192 | 4,820,232 | 5,141,657 | **4,622,445** |
| **Scenario** | | | | | | | | | | |
| *Production* | **16,423,928** | **17,799,206** | **18,865,431** | 20,146,331 | **18,308,724** | 16,499,774 | 17,811,953 | 18,888,677 | 20,244,783 | **18,361,297** |
| Irrigated | 12,365,645 | 13,445,543 | 14,153,737 | 15,055,305 | **13,755,057** | 12,465,984 | 13,406,307 | 14,119,062 | 15,157,630 | **13,787,246** |
| Rainfed | 4,058,283 | 4,353,663 | 4,711,694 | 5,091,027 | **4,553,667** | 4,033,790 | 4,405,645 | 4,769,615 | 5,087,153 | **4,574,051** |
| **CNCM3** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Production* | **16,315,899** | **17,721,337** | **18,642,879** | 20,092,749 | **18,193,216** | 16,371,675 | 17,588,396 | 18,829,762 | 20,256,070 | **18,261,476** |
| Irrigated | 12,159,989 | 13,104,325 | 13,889,319 | 14,832,483 | **13,496,529** | 12,230,783 | 13,052,744 | 13,968,273 | 15,116,391 | **13,592,048** |
| Rainfed | 4,155,910 | 4,617,012 | 4,753,559 | 5,260,266 | **4,696,687** | 4,140,892 | 4,535,652 | 4,861,490 | 5,139,678 | **4,669,428** |
| **Scenario** | | | | | | | | | | |
| *Production* | **16,398,862** | **17,808,861** | **18,733,384** | 20,187,083 | **18,282,047** | 16,455,291 | 17,675,030 | 18,920,846 | 20,352,393 | **18,350,890** |
| Irrigated | 12,284,692 | 13,238,140 | 14,028,310 | 14,980,593 | **13,632,934** | 12,356,634 | 13,185,660 | 14,108,999 | 15,266,720 | **13,729,503** |
| Rainfed | 4,114,170 | 4,570,720 | 4,705,074 | 5,206,490 | **4,649,114** | 4,098,658 | 4,489,370 | 4,811,847 | 5,085,673 | **4,621,387** |
| **MPEH5** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Production* | **16,367,265** | **17,697,619** | **18,878,885** | 20,171,416 | **18,278,796** | 16,308,476 | 17,553,461 | 18,848,614 | 20,147,284 | **18,214,459** |
| Irrigated | 12,331,554 | 13,226,953 | 14,062,027 | 14,900,558 | **13,630,273** | 12,266,633 | 13,175,441 | 14,202,062 | 15,043,049 | **13,671,796** |
| Rainfed | 4,035,712 | 4,470,666 | 4,816,859 | 5,270,858 | **4,648,524** | 4,041,843 | 4,378,019 | 4,646,552 | 5,104,236 | **4,542,663** |
| **Scenario** | | | | | | | | | | |
| *Production* | **16,451,772** | **17,785,906** | **18,970,532** | 20,265,898 | **18,368,527** | 16,392,136 | 17,640,907 | 18,941,096 | 20,242,956 | **18,304,274** |
| Irrigated | 12,457,430 | 13,361,449 | 14,204,134 | 15,050,092 | **13,768,276** | 12,391,791 | 13,308,979 | 14,344,065 | 15,193,401 | **13,809,559** |
| Rainfed | 3,994,342 | 4,424,457 | 4,766,398 | 5,215,806 | **4,600,251** | 4,000,345 | 4,331,928 | 4,597,031 | 5,049,555 | **4,494,715** |
| **Average of 3 GCMs** | | | | | | | | | | |
| Base | | | | **20,105,325** | **18,230,427** | | | | **20,184,253** | **18,249,131** |
| Scenario | | | | **20,199,771** | **18,319,766** | | | | **20,280,044** | **18,338,820** |
| % change | | | | **0.47** | **0.49** | | | | **0.47** | **0.49** |

**Annex B. Policy Simulation on Rice Farmgate Prices, 2011-2030**

| Global Circulation Models | PAM Model Policy Simulation (2011-2030) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1B Scenario | | | | | A2 Scenario | | | | |
| | 2011-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2011-2030 | 2011-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2011-2030 |
| **BCM2** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Farmgate Price* | 16.853 | 20.877 | 25.438 | 30.199 | **23.342** | 16.552 | 20.825 | 25.297 | 29.573 | **23.062** |
| **Scenario** | | | | | | | | | | |
| *Farmgate Price* | 16.500 | 20.440 | 24.915 | 29.583 | **22.859** | 16.203 | 20.391 | 24.778 | 28.968 | **22.585** |
| **CNCM3** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Farmgate Price* | 16.944 | 20.817 | 26.247 | 29.927 | **23.484** | 16.715 | 21.519 | 25.111 | 28.927 | **23.068** |
| **Scenario** | | | | | | | | | | |
| *Farmgate Price* | 16.590 | 20.388 | 25.706 | 29.319 | **23.001** | 16.364 | 21.077 | 24.596 | 28.332 | **22.592** |
| **MPEH5** | | | | | | | | | | |
| **Base** | | | | | | | | | | |
| *Farmgate Price* | 16.740 | 20.927 | 24.821 | 29.430 | **22.980** | 17.003 | 21.676 | 24.994 | 29.594 | **23.317** |
| **Scenario** | | | | | | | | | | |
| *Farmgate Price* | 16.386 | 20.491 | 24.310 | 28.834 | **22.505** | 16.645 | 21.225 | 24.475 | 28.986 | **22.833** |
| **Average of 3 GCMs** | | | | | | | | | | |
| Base | | | | **29.852** | **23.268** | | | | **29.365** | **23.149** |
| Scenario | | | | **29.245** | **22.788** | | | | **28.762** | **22.670** |
| % change | | | | **-2.03** | **-2.06** | | | | **-2.05** | **-2.07** |