RESEARCH ARTICLE

Climate Change, Food Availability, and Poverty: The Case of Philippine Rice

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Abstract: The Philippines is experiencing the effects of wide swings in weather conditions in recent years. The country experienced super typhoons, floods, and extended periods of drought recurring in most of the regions. The agricultural commodity that is severely affected by climate change is rice, which is the staple food of Filipinos. Using a computable general equilibrium model calibrated to Philippine data, the paper analyzes the effects of climate change as it affects palay productivity. The analysis looks at the impact on palay production and rice supply, prices, consumption, household income, and welfare. The paper extends the analysis by computing the income distribution and poverty effects of the productivity changes by applying a poverty microsimulation using the 2012 Family Income and Expenditure Survey. The results indicate that climate change decreases palay production in rainfed (or non-irrigated) areas, leading to higher prices, reduced rice consumption, decreased real income of households, decreased welfare, increased income inequality, and poverty. These effects however are minimized or reversed if the limits imposed by the government on rice imports are relaxed. If the government reduces the trade barriers on imported rice which is considerably cheaper than domestically produced rice, supply of rice improves which decreases prices, rice consumption increases, real household improves, welfare increases, and income inequality and poverty decrease.

Keywords: climate change, irrigation, rice, poverty

JEL Classifications: C15, C68, I38, Q15, Q18, Q23, Q54

The Philippines has been experiencing extreme weather changes in the last decade. The frequency of very strong typhoons that entered the country's area of responsibility has increased over the past 15 years, which brought about significant damages to agricultural production. Major cyclones that devastated the country include: Typhoon Haiyan (Yolanda) in 2013, Typhoon Bopha (Pablo) in 2012, Typhoon Nesat (Pedring) in 2011, Typhoon Megi (Juan) in 2010, Typhoon Ketsana (Ondoy) in 2009, Typhoon Reming (Durian) in 2006, and Depression Winnie in 2004. Over the same period, there were also increasing incidence of extended droughts in different parts of the country. One of the most affected agricultural products is rice, which is the staple food of about 80% of Filipinos and a major item in the consumption budget. The paper analyzes the impact of climate change on rice production particularly in rainfed (or unirrigated) areas, with respect to these variables: prices, consumption, household income, poverty, and income distribution. In light of these effects, the paper also looks into possible policy changes that can minimize the negative impact on households. The analysis uses a computable general equilibrium model and poverty microsimulation.

Philippine Rice

Importance of Rice

In the 2012 Family Income Expenditure Survey (FIES), rice consumption is 19% of the total consumption of poor households and 10% for non-poor (see Table 1). Rice is an important agricultural crop in the Philippines because it is a major source of income

Table 1. *Food Consumption in the Philippines*

	Poor					Non-poor				
	1997	2000	2003	2009	2012	1997	2000	2003	2009	2012
	Philippines /a/									
Total Food /b/	64.6	63.3	62.6	52.0	60.99	49.9	48.1	47.7	43.0	45.6
Cereals /c/	30.2	27.9	27.0	25.7	25.6	15.3	13.5	12.8	13.1	12.2
Rice /d/				22.5	19				11.3	9
	Rural									
Total Food	64.9	64.2		51.0	57.78	53.2	52.0		43.1	46
Cereals	30.9	29.6		25.9	22.1	19.0	17.2		15.2	10.8
Rice				22.7	16				14.1	7
	Urban									
Total Food	63.3	61.1		56.1	61.8	47.5	45.4		42.9	45.1
Cereals	27.7	23.6		24.9	26.5	12.5	10.9		11.2	13.8
Rice				21.8	20				8.7	10

Sources: Philippine Statistical Authority (1997, 2000, 2003, 2009 2012).
/a/ No rural and urban breakdown in 2003 FIES
/b/ Percent of total consumption
/c/ Includes rice and corn
/d/ Cereals were disaggregated into rice, corn, and other cereals in 2009 and 2012 FIES

Table 2. *Rice a Major Crop in the Philippines*

	2012			**2013**			**2014**			**2015**		
	Area /a/	**Quantity/b/**	**Value /c/**	**Area**	**Quantity**	**Value**	**Area**	**Quantity**	**Value**	**Area**	**Quantity**	**Value**
Palay	35.1	20.5	36.6	35.6	21.5	38.6	35.5	21.8	33.9	35.2	21.5	36.3
Corn	19.4	8.4	11.8	19.2	8.6	11.1	19.6	8.9	9.7	19.4	8.9	10.8
Coconut	26.8	18.0	11.1	26.6	17.9	10.1	26.2	16.9	11.3	26.6	17.5	11.1
Sugarcane	3.2	30.0	5.3	3.3	28.7	4.9	3.2	28.8	4.5	3.2	27.2	5.0
Other crops	15.4	23.1	35.1	15.3	23.3	35.3	15.5	23.6	40.6	15.7	24.9	36.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Philippine Statistical Authority (2016).
/a/ Share of total agricultural land.
/b/ Share of total quantity (thousand metric tons) of agricultural commodities
/c/ Share of total value of agricultural production

for millions of Filipino farmers. Palay (unhusked rice, the local name of paddy) production uses 35% of agricultural land (see Table 2) and contributes almost 40% to the total value of agricultural production.

Rice Production

While almost all regions in the country grow palay, 53% of production comes from only four regions: Region 2 (Central Luzon) which contributes 18.8% to the total; Region 2 (Cagayan Valley) contributes 13.4%; Region 6 (Western Visayas) contributes 11%; and Region 1 (Ilocos Region) contributes 9.8% (see Table 3). Despite these regions being the primary producers of rice, not all regions are adequately irrigated. The two largest producers of palay (Regions 2 and 3) are more than 90% irrigated, while Region 6 (the third largest) is only 51.5% irrigated. Irrigation is also relatively limited in the rest of the Visayas regions. However, three regions in Mindanao (10, 11, 12) have wide rice fields which are irrigated.

Irrigation

Irrigation is critical in rice production. Appropriate amount of chemical inputs can be properly implemented in production if there is an adequate level of water and moisture. This is the reason why the productivity in irrigated rice areas (yield measured as metric ton per hectare) is 42.6% higher than in rainfed (unirrigated) areas (Table 4). However, while irrigation is important, its impact on yield is not uniform across regions. The productivity of irrigation in Region 2 is 69% higher than non-irrigated area. The same is true in Region 15

Table 3. *Philippine Palay Production*

		(2)			Yield (3)		
	(1)	Irrigated	Rain-fed	Total	Irrigated	Rain-fed	% diff. (4)
Overall Philippines	100.0	75.8	24.2	100.0	4.30	3.02	42.6
Region 1 - Ilocos Region	9.8	72.4	27.6	100.0	4.55	3.84	18.4
Region 2 - Cagayan Valley	13.4	91.9	8.1	100.0	4.43	2.62	69.0
Region 3 - Central Luzon	18.8	91.7	8.3	100.0	4.99	3.74	33.3
Region 4a - CALABARZON /a/	2.2	80.4	19.6	100.0	3.86	2.51	54.0
Region 4b - MINAROPA/b/	5.9	71.6	28.4	100.0	3.96	3.30	19.8
Region 5 - Bicol Region	6.9	71.0	29.0	100.0	3.94	3.09	27.6
Region 6 - Western Visayas	11.0	51.5	48.5	100.0	3.68	3.02	21.9
Region 7- Central Visayas	1.7	64.4	35.6	100.0	3.56	2.63	35.5
Region 8 - Eastern Visayas	5.4	56.7	43.3	100.0	4.29	2.84	51.0
Region 9 - Zamboanga Peninsula	3.5	64.7	35.3	100.0	4.38	3.32	32.0
Region 10 - Northern Mindanao	3.8	90.4	9.6	100.0	4.48	3.33	34.6
Region 11 - Davao Region	2.4	90.9	9.1	100.0	4.48	3.03	47.9
Region 12 - SOCCSKSARGEN /c/	7.1	82.1	17.9	100.0	4.05	2.99	35.3
Region 13 - CARAGA /d/	2.8	63.3	36.7	100.0	3.44	2.77	24.0
Region 14 - Auto. Region Muslim Mindanao	3.0	30.8	69.2	100.0	3.35	2.37	41.8
Region 15 - Cordillera Admin. Region	2.4	86.1	13.9	100.0	4.05	2.40	68.9

Sources: Philippine Statistical Authority (2012 to 2016)
(1) Regional sources of rice production, average production share in 2012–2016, %
(2) Regional irrigation, average % distribution in 2012–2016
(3) Metric ton per hectare, average in 2012–2016
(4) Yield difference, irrigated versus rain-fed
/a/Southern Tagalog Mainland
/b/ Southwestern Tagalog Region
/c/ Administrative Region in South-Central Mindanao
/d/ Administrative Region in Northeastern Mindanao

Table 4. *Irrigation and Irrigation Provider in the Philippines (Average % Share in 2013–15)*

	Estimated Total Irrigable Area			Firmed-up Service Area				
	Total	Firmed-up Service Area	Potential Area for Development	National Irrigation System	Communal Irrigation System	Private Irrigation System	Others	Total
Philippines	100.0	56.5	43.5	43.9	34.9	11.3	9.9	100.0
Region 1 - Ilocos Region	100.0	64.9	35.1	27.5	30.4	12.4	29.7	100.0
Region 2 - Cagayan Valley	100.0	60.1	39.9	54.5	19.5	17.6	8.4	100.0
Region 3 - Central Luzon	100.0	60.8	39.2	66.6	23.2	2.8	7.3	100.0
Region 4a - CALABARZON /a/	100.0	55.8	44.2	42.9	38.9	12.9	5.3	100.0
Region 4b - MINAROPA/b/	100.0	52.5	47.5	26.0	44.7	19.8	9.5	100.0
Region 5 - Bicol Region	100.0	55.8	44.2	17.3	53.4	18.8	10.5	100.0
Region 6 - Western Visayas	100.0	60.1	39.9	41.2	32.1	13.3	13.4	100.0
Region 7- Central Visayas	100.0	92.0	8.0	27.0	58.9	10.7	3.3	100.0
Region 8 - Eastern Visayas	100.0	82.2	17.8	32.2	54.4	8.8	4.5	100.0
Region 9 - Zamboanga Peninsula	100.0	60.3	39.7	36.5	51.5	4.2	7.9	100.0
Region 10 - Northern Mindanao	100.0	53.8	46.2	42.1	41.7	10.2	6.0	100.0
Region 11 - Davao Region	100.0	43.9	56.1	55.3	37.8	2.4	4.5	100.0
Region 12 - SOCCKSKSARGEN /c/	100.0	39.7	60.3	56.7	31.1	2.8	9.4	100.0
Region 13 - CARAGA /d/	100.0	42.2	57.8	77.1	15.7	2.5	4.7	100.0
Region 14 - Auto. Region Muslin Mindanao	100.0	29.2	70.8	56.2	42.9	0.2	0.6	100.0
Region 15 - Cordillera Admin. Region	100.0	92.9	7.1	15.5	52.8	29.1	2.6	100.0

Source: National Irrigation Administration (2016).

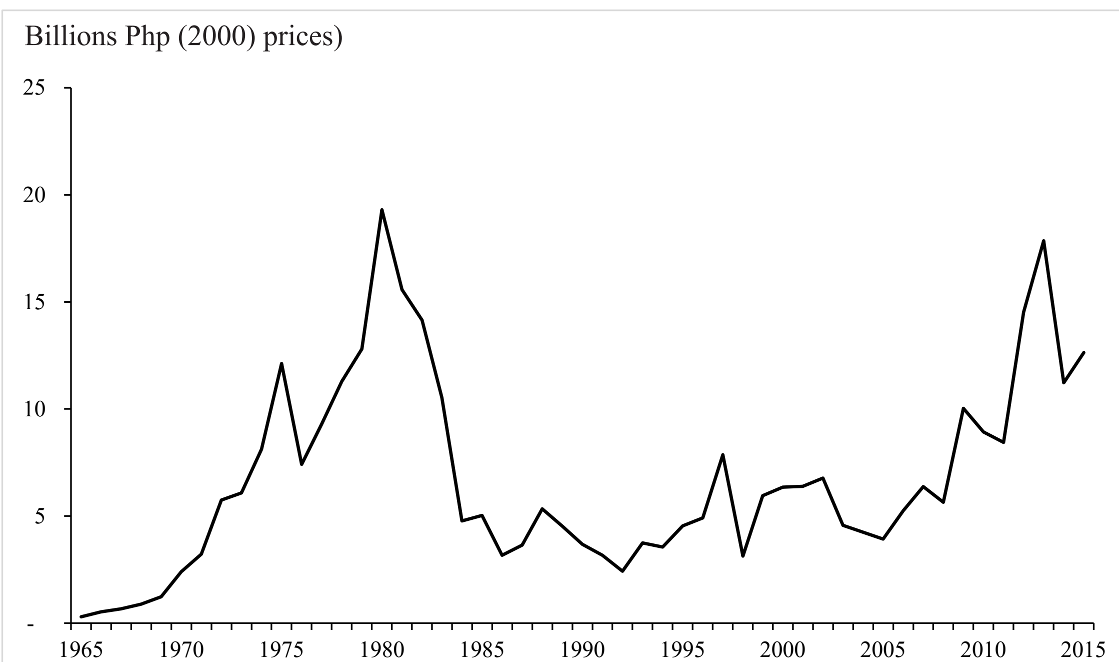
(the Cordillera Administrative Region). The lowest yield advantage of irrigated rice field compared to non-irrigated is in Regions 5 and 6.

Table 4 summarizes the structure of irrigation system in the various regions in the country by type of system. Not all agricultural (rice) areas in the regions are irrigable. Of the irrigable area in the country, only 56.4% is irrigated based on the firmed-up service area. Based on this estimate, there is still a maximum of 43.5% of irrigable land, which is potential for irrigation development, assuming water would be available and that the economics will justify the investments.

There are two types of systems: the national irrigation systems (NISs) and the communal irrigation systems (CISs). The NISs are owned by the National Irrigation Authority (NIA) and co-managed with the irrigators' associations. Overall, the NISs cover 43.9% of the service areas. An NIS is supposed to irrigate at least 1,000 hectares.

The CISs, which are owned and managed by farmers (irrigators' association) with technical support by NIA, cover 34.9% of the service areas. The CIS irrigates areas below 1,000 hectares. The CIS started as purely private initiatives, but over the decades, it increasingly received significant government support for the cost of rehabilitation and new construction. Most CIS are constructed by NIA, but the irrigator associations are responsible for the management and maintenance of the systems. The private sector provides 11.3% of the irrigation services. In Table 4, "Others" include funding from various foreign governments.

Figure 1 shows the trends in irrigation investments by the national government from the mid 1960s to 2015. Over the past five decades, public capital investments in irrigation have fluctuated significantly, rising in the 1970s, declining drastically in 1983, and recovering to some extent in the early 1990s. The sharp increase in world rice prices in the 1970s, together with the introduction of modern rice varieties suited to irrigated conditions, raised the marginal rates of returns to irrigation investments. Public spending on irrigation declined as world commodity prices declined, yields of modern rice varieties leveled off, and the cost of irrigation expansion increased. Investments have risen again since 2008, likely in response to increased world rice prices, and this trend has continued with the present administration's food self-sufficiency program. More systematic analyses indicate that public investment levels respond to short-term changes in world rice prices because these changes affect the marginal rate of return to irrigation investment and the adoption of rice self-sufficiency rather than a consideration of the



Source: Inocencio (in press)

Figure 1. Trends in irrigation investment, 1965-2015.

Table 5. *Fertilizer Use*

	Area Planted /1/	Area Applied /1/		Ave. Fertilizer /2/ Use Per Hectare
		Area	%	
		Irrigated		
1991	2.1	1.9	90.5	3.8
1995	2.4	2.2	93.7	4.1
1998	2.3	2.0	89.4	4.6
2002	2.7	2.6	96.9	4.9
		Non-irrigated		
1991	1.4	1.0	70.0	3.3
1995	1.4	1.0	67.3	3.6
1998	1.0	0.6	64.0	3.6
2002	1.3	1.1	79.5	3.8

Source: Philippine Statistics Authority (2015)
/1/ Million hectares
/2/ All types of fertilizer, bag of 50 kilograms

Table 6. *Impact of Climate Change on Rice Yield in the Philippines*

	Irrigated			Rainfed		
	Low /a/	High /b/	Average	Low	High	Average
Luzon	-0.20	-0.10	-0.15	-7.40	-7.70	-7.55
Visayas	-1.10	-0.60	-0.85	-4.10	-3.90	-4.00
Mindanao	-0.80	0.70	-0.05	-0.50	-0.60	-0.55
Philippines	-0.40	0.00	-0.20	-4.50	-4.50	-4.50

long-term costs and benefits (Hayami & Kikuchi, 1978; Kikuchi, Maruyama, & Hayami, 2003).

The data in Table 5 extends only until 2002, but the trend clearly shows the application of fertilizer is higher in irrigated fields. Of the total irrigated rice fields, 97% applied fertilizer. On the average, 4.9 bags (of 50 kilograms) of fertilizer were applied per hectare in irrigated area. In the same year, 80% of non-irrigated area was applied with fertilizer. On the average, 3.8 bags of fertilizer were used in non-irrigated rice area.

Climate Change

A recent study that examined the potential impact of climate change on Philippine agriculture indicates that irrigation is a key factor that can minimize the adverse effects of wide swings in weather conditions on agriculture production (Thomas, Pradesha, & Perez, 2015). The study examined the pattern of climate changes during the period 1950–2000 to get the swings in weather conditions as indicated by the levels of rainfall during the wettest and the driest periods. Changes in weather conditions have different effects in the three major islands in the Philippines (Luzon, Visayas, and Mindanao). Using global models, the study projects the effects in the next 50 years, 2000–2050. Table 6 summarizes the results of the study on rice.

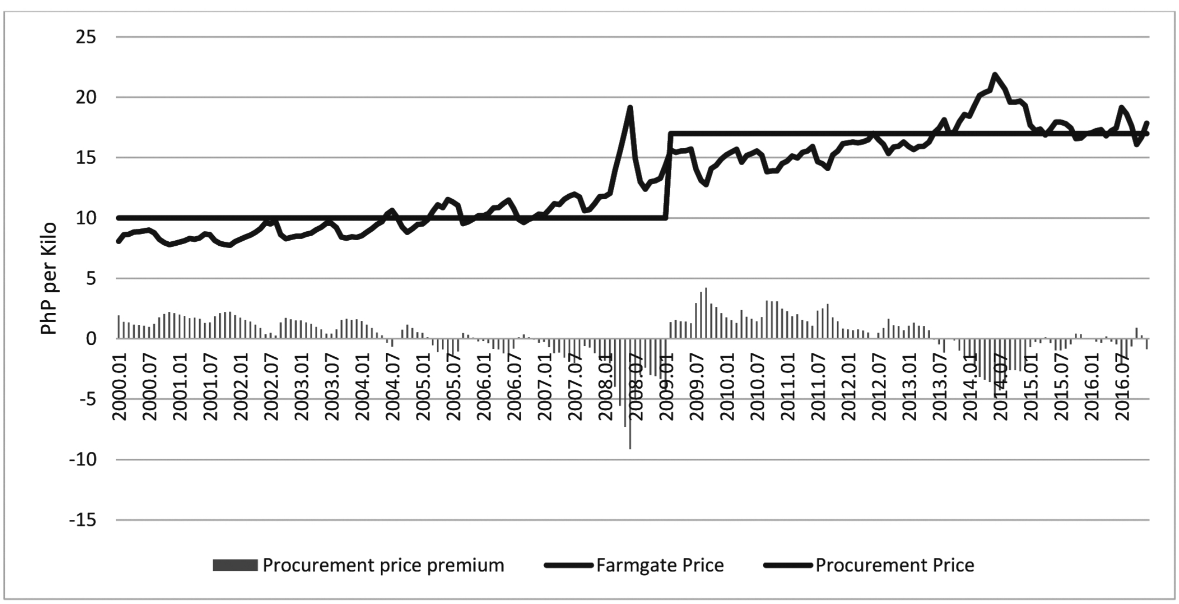
On the average, climate change has negligible effects on the yields in irrigated rice with adequate use of fertilizer. However, there are different effects across the regions. Under the "High" column, climate change reduces rice yield in Luzon by 0.1%. The negative effect in Visayas is slightly higher at -0.6%, but the effect in Mindanao is positive 0.7%. There are negative effects on yield in irrigated rice under the low fertilizer use scenario, that is, overall, yield declines by 0.4%.

The negative effects on yield are significantly higher in rainfed areas. In both the "Low" and "High" fertilizer use scenarios, the overall yield declines by 4.5%. This result implies that even if the application of chemical inputs is increased in rainfed rice areas, the use of fertilizer will not mitigate the negative effects of changes in weather conditions on yield. Rainfed rice areas in Luzon are severely affected, with yield declining by 7.6%. The impact in Visayas is also high at -4.0%. The impact in Mindanao is also negative but a lot lower.

Philippine Rice Policy

During the harvest season, palay supply surges and palay prices decline. To stabilize the market, the government, through the NFA, procures palay from the farmers at the support price. During the years 2000–2016, there were several periods when farmgate prices settled at levels below the NFA support price as seen in Figure 2. This is seen in the positive procurement price premium (the difference between the support and farmgate prices) in 2000–2004 and 2009–2013 and some months in 2016. In 2009–2013 when the price premium was at its highest levels, in spite of relatively higher procurement ratio during the periods, the farmgate price failed to catch up with the support price (see Table 7). This was largely due to NFA's lack of financial resources to support an aggressive procurement program because of its chronic deficit. After 2013, farmgate prices have slowly caught up with the support price with some periods in 2014 yielding negative premium for selling rice to the NFA.

In 2003, the Arroyo administration ordered the NFA to allow rice farmer federations and cooperatives to import rice as it was seen to be highly profitable. High profits came from sales commissions, as well as from the Private Sector Financed Importation Tax Expenditure Subsidy (PSF-TES) where rice importers avail of the privileges of the NFA to waive import duties. Rice imports beyond 350 thousand metric tons are supposedly charged with 40% tariff but through the PSF-TES, rice importers are exempt from paying these duties. These taxes are instead shouldered by the Philippine government through the Department of Finance's Fiscal Incentives Review Board. Furthermore, although private rice importers buy rice in behalf of the NFA, the rice stocks they bought are not part of NFA's inventory but sold to the domestic market



Sources: Philippine Statistics Authority (2016); National Food Authority (2016).

Figure 2. Farmgate and support price of palay (PhP per kilo).

Table 7. ***Production and NFA Intervention in Palay and Rice (Thousand Metric Tons)***

	NFA Intervention						
	Palay Production		Procurement		Rice	Rice	Rice
	Production	% growth	Palay	% of production	Injection	Importation	Consumption /1/
2000	12,389	5.1	663	5.4	1,169	617	8,050
2001	12,955	4.6	474	3.7	813	739	8,512
2002	13,271	2.4	300	2.3	1,239	1,238	9,201
2003	13,500	1.7	296	2.2	1,120	698	8,798
2004	14,497	7.4	208	1.4	1,342	984	9,682
2005	14,603	0.7	76	0.5	1,666	1,754	10,515
2006	15,327	5.0	74	0.5	1,615	1,628	10,824
2007	16,240	6.0	33	0.2	1,883	1,790	11,534
2008	16,814	3.5	683	4.1	2,027	2,341	12,430
2009	16,266	-3.3	471	2.9	1,808	1,575	11,335
2010	15,772	-3.0	502	3.2	1,759	2,217	11,680
2011	16,685	5.8	275	1.6	1,113	251	10,262
2012	18,032	8.1	361	2.0	766	120	10,940
2013	18,439	2.3	366	2.0	759	405	11,469
2014	18,967	2.9	27	0.1	1,317	1,080	12,461
2015	18,149	-4.3	228	1.3	943	988	11,878
2016	17,627	-2.9	108	0.6	1,052	891	11,467

Sources: National Food Authority (2017); Philippine Statistics Authority (2017).
/1/ Estimates based on 60% of palay production (milling recovery rate) plus imports

at wholesale prices which are above the NFA release price. This practice continues to be implemented over the years, with the minimum access volume (MAV) varying on year to year basis.

One of NFA's mandates is to make rice available to Filipino consumers at affordable prices, however, the data would suggest otherwise. The regular-milled wholesale price of 25% broken rice is compared with the NFA release price, the FAO export price of Thai rice (25% broken), the FAO export price of Vietnam rice (25% broken), and the NFA release price discount (the difference between wholesale price and the NFA release price). The wholesale price was above the NFA release price since 2004. Over the past five years, the difference between the wholesale and the NFA release price continues to increase with a peak year-on-year growth of 352% in July 2014. This indicates that the NFA has not been successful in stabilizing local rice prices. This is attributed largely to the NFA's chronic income imbalance.

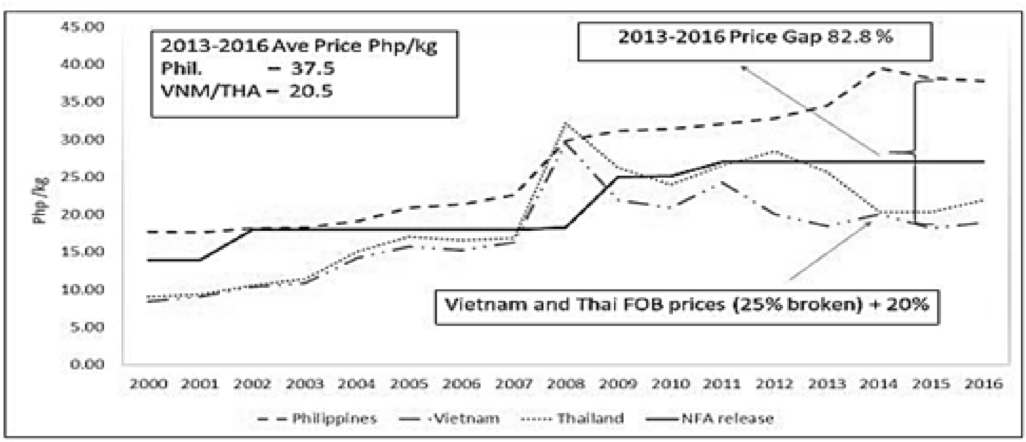
The Philippines imports more than three-quarters of its rice import requirements from Vietnam because the rice qualities are similar to the local rice. Based on the current trend, the gap between the two prices is widening, with the local price is increasing while Vietnam's price is declining (see Table 8). In 2012, the price gap was PhP12.70 per kilo. The gap increased by 26.0% in 2013 to PhP16.00 per kilo. This gap continues to widen as in 2016, the gap was at PhP 18.91 per kilo, a 48.9% increase from 2012 prices. In 2015, the price gap peaked at PhP19.90 per kilo, where the price gap is more expensive than an actual kilo of rice from Vietnam.

Therefore, Filipinos are paying high prices of rice. In the last four years (2013–2016), the average price of domestic rice is 82.8% higher than the CIF (cost, insurance, and freight) price of rice in Vietnam and Thailand as Figure 2 illustrates. These are prices of similar quality, which is categorized as class C or 25% broken. The price difference is due to the import

Table 8. *Comparative Prices of Rice (Php/kg)*

	Philippines	Vietnam /a/	Thailand /a/	NFA release
2000	17.77	8.43	9.12	14.00
2001	17.61	9.06	9.36	14.00
2002	18.21	10.40	10.59	18.00
2003	18.30	10.86	11.45	18.00
2004	19.12	14.26	15.13	18.00
2005	20.93	15.80	17.12	18.00
2006	21.39	15.33	16.56	18.00
2007	22.59	16.28	16.89	18.00
2008	29.81	29.51	32.18	18.25
2009	31.17	21.95	26.30	25.00
2010	31.45	20.95	24.03	25.17
2011	32.06	24.27	26.56	27.00
2012	32.82	20.12	28.38	27.00
2013	34.49	18.49	25.67	27.00
2014	39.51	20.08	20.35	27.00
2015	38.14	18.24	20.37	27.00
2016	37.83	18.92	21.94	27.00

Source: International Rice Research Institute (2017).
/a/ 25 % broken; includes 20 % transport cost



Source: International Rice Research Institute (2017)

Figure 3. Wholesale, NFA release, Thai rice, and Vietnam rice prices (PhP per kilo).

control by the National Food Authority (NFA). The NFA controls the amount of rice imports through quantitative restrictions (QR), which artificially increases the domestic price of rice. At present, the Philippines is the only World Trade Organization (WTO)-member country that imposes QR.

Therefore, because of the importance of rice, the government has been heavily involved in the rice market with its regulations dating back to the 1960s. In 1972, the government established the National Food Authority (NFA) to help the country move towards rice self-sufficiency. Since its founding, the NFA has been heavily involved in the procurement of paddy as well as in the importation and distribution of rice. Its two primary mandates are to ensure that consumers have an adequate supply of rice at affordable prices and to help rice farmers receive reasonable returns.

Framework of Analysis

The analysis uses two simulation models: (a) a Philippine Computable General Equilibrium Model (PCGEM); and (b) a Philippine Poverty Microsimulation (PovSIM). PCGEM, was calibrated using a Philippine Social Accounting Matrix (PSMA) for 2015. PovSIM uses the 2012 FIES. Detailed discussion of PCGEM and PovSim is found in Cororaton et al. 2016. PCGEM generates results on sectoral production, consumption, prices, factor demand, household income, and welfare. The discussion will focus on the effects on palay and rice, as well as on prices, household income, and welfare. Some of these results are utilized in PovSIM to calculate the effects on poverty and income distribution.

Definition of Simulations

Apart from the baseline, two simulations were carried out to analyze the effects of climate change on Philippine rice:

a). SIM 1 – This scenario involves a reduction in rice productivity as a result of climate change. In this simulation, the results of Thomas et al.'s (2015) study of a 4.5% reduction is followed with the reduction rounded off to a reduction of 5%. The decline in palay productivity is introduced by reducing the scale parameter of the production of palay by 5%, which is expected to decrease the local production of palay and rice, as well as to increase their prices. Based on Thomas et al., this reduction in productivity would be near zero for irrigated rice areas.

b). SIM 2 – This is SIM 1 plus a reduction in the trade barriers on rice imports by cutting in half both the in-quota tariff rate on rice (originally at 35%) and the out-quota tariff rate (originally at 40%). The reduction in these tariff rates is expected to reduce import prices of rice and to increase the flow of imported rice, which will minimize the effects of climate change on rice supply in the domestic market and its corresponding prices.

Simulation Results

SIM 1 – The Effects of Climate Change

The reduction in yield (productivity) in palay production as a result of climate change decreases the volume of production of palay by 1.1% and prices by 5.3% (see Table 9). Rice, which is processed palay, is affected similarly; its volume declines by 1.2% and price increases by 2.3%. The consumer price of rice increases by 2%, which decreases household rice consumption by 0.5%.

Table 9. *Effects on Palay and Rice (% Change From Base)*

	Volume	Prices
Production		
Palay	-1.081	5.254
Rice	-1.228	2.307
Consumption		
Palay	-1.074	5.231
Rice	-0.456	2.033

Source: Authors' estimates (2017).

The reduction in the production of palay and rice as a result of climate change has small, but negative impact on nominal income of households. The negative income effect is relatively higher in lower income groups (see Table 10) and at the same time, consumer prices increases. The increase however is significantly higher in lower income groups because rice is a major item in the consumption basket. The reduction in income, together with the increase in consumer prices, results to lower real household income. The reduction in real income is notable in lower income groups and this implies that the negative effects of climate change is biased against poor households as they are negatively affected than richer groups. Overall, the negative economic impact of climate change is a reduction of welfare by Php7.5 billion (see Table 11). This reduction in welfare can be taken as the maximum amount which would have been kept if the palay production had been fully irrigated.

The effects on income distribution and on poor households are presented in Table 12 and is indicated by the GINI coefficient. A GINI coefficient of 0 implies perfect equality in the distribution of income, while a value of 1 means perfect inequality. The Philippine GINI coefficient is 0.4713, which says that there is

Table 10. *Effects on Household Income and Prices, (% Change From Base)*

	Nominal Income	Prices	Real Income
h1	-0.059	0.348	-0.407
h2	-0.055	0.334	-0.389
h3	-0.052	0.293	-0.345
h4	-0.048	0.248	-0.296
h5	-0.041	0.200	-0.241
h6	-0.038	0.162	-0.199
h7	-0.033	0.128	-0.162
h8	-0.031	0.092	-0.124
h9	-0.031	0.056	-0.087
h10	-0.020	0.009	-0.030

Source: Authors' estimates (2017).

Table 11. *Effects on Welfare, Php Billion*

Equivalent Variation	-7.471

Source: Authors' estimates (2017).

a high degree of income inequality in the country. Climate change will worsen the inequality by 0.05% because of the higher reduction in household income in the lower income groups as indicated in Table 10.

Poverty is indicated by three indices: P0 indicates the incidence of poverty, P1 the poverty gap, and P2 the poverty severity. P0 is the ratio of poor to the overall population. P1 measures the gap between the average income of the poor and the poverty threshold. P2 is taken as the squared value of P1, which measures the degree of inequality among poor. Higher values of P2 implies a higher number of poor people that are extremely below the poverty threshold and are considered to be severely poor people.

The results in Table 12 indicate that climate change will not only increase the number of poor people, but it will also worsen those in extreme poverty. This is shown by the increase in P2 index. The urban poor is severely affected because it is relatively a net consumer of rice as compared to the rural poor. This implies that the urban poor's ability to switch to alternatives is relatively lower than of the rural poor even if the price of rice increases due to climate change.

Table 12. *Effects on Poverty and Income Distribution*

		Base 2012	SIM	
		Level	Level	% change from base
GINI Coefficient		0.47126	0.47149	0.049
Philippines	P0	24.848	24.927	0.316
	P1	6.836	6.870	0.490
	P2	2.679	2.695	0.620
Urban	P0	11.570	11.664	0.813
	P1	2.794	2.814	0.732
	P2	0.989	0.999	0.936
Rural	P0	35.584	35.650	0.186
	P1	10.105	10.149	0.436
	P2	4.044	4.067	0.557

Source: Authors' estimates (2017).
P0 - poverty incidence
P1- poverty gap
P2- poverty severity

Taking the results of Thomas et al. (2015), investments in irrigation can arrest the potential declines in palay productivity, which in turn can mitigate the decreases in incomes of households, decrease in welfare, increase in the number of poor, and worsening income inequality.

SIM 2 – Effects of Climate Change with Reduced Rice Trade Barriers

SIM 1 indicates notable increases in the price of rice as a result of climate change. This is due to the limitation in the supply of domestically produced rice. However, as discussed above, even without the climate change effects, Filipino consumers are already paying extremely high prices of the rice they eat as the government controls/limits the other important source of rice supply such as rice imports. The government imposes extremely high trade barriers on imported rice, which results in Filipinos paying more than 80% of the world price for the rice they consume.

To reduce the negative impact of climate change, SIM 2 illustrates the scenario when the government reduces the trade barriers on rice imports in order to increase the overall rice supply in the domestic market. To implement this scenario, both the in-quota and out-quota tariffs were reduced by 50%. This reduces the price of imported rice in the domestic market by 14.2% and this further increases rice imports by 42.5% and improves the overall supply of rice in the domestic market (see Table 13). Due to the increase in imported rice, the consumer price of rice decreases by 3.2% and consequently increases rice consumption by 0.7%.

Table 13. *Effects on Palay and Rice (% Change From Base)*

	Volume	Prices
Production		
Palay	-3.588	3.990
Rice	-4.265	-1.580
Consumption		
Palay	-3.583	3.979
Rice	0.713	-3.201
Imports		
Rice	42.473	-14.290

Source: Authors' estimates (2017).

There are two factors affecting the change in nominal income of households in Table 14: (a) the displacement effects of rice imports on rice farmers, which are mostly in the lower income brackets; and (b) the reduction in the rice quota rent that goes to the richest household, h10. Due to the displacement effects of rice imports on rice farmers among non-rice quota income earners (h1 to h9), the reduction in nominal income is higher in h1. Consequently, because of the reduction in the rice quota rent that goes to the richest households, the 50% reduction in the in-quota and out-quota tariff rates results in a higher reduction in income in h10. Furthermore, the decrease in the consumer price is relatively higher in the lower income groups because of the larger share of rice in their consumption basket. The results indicate that the reduction in consumer prices dominates the negative income effects in the lower households (h1 to h6). However, negative income effects dominate in the higher income households (h7 to h10). Overall, the welfare of the economy expands by Php1.6 billion (see Table 15).

Table 14. *Effects on Household Income, (% Change From Base)*

	Nominal Income	Prices	Real Income
h1	-0.430	-0.726	0.296
h2	-0.425	-0.686	0.262
h3	-0.424	-0.623	0.199
h4	-0.422	-0.558	0.137
h5	-0.418	-0.490	0.072
h6	-0.414	-0.441	0.026
h7	-0.409	-0.397	-0.012
h8	-0.405	-0.356	-0.049
h9	-0.397	-0.320	-0.076
h10	-0.504	-0.262	-0.242

Source: Authors' estimates (2017).

Table 15. *Effects on Welfare, Php Billion*

Equivalent Variation	1.632

Source: Authors' estimates (2017).

The results in Table 16 show that the negative climate change effects on poverty and income distribution can be offset by the reduction in the trade

Table 16. *Effects on Poverty and Income Distribution*

	Poverty measures	Base 2012	SIM	
		Level	Level	% change from base
GINI Coefficient		0.47126	0.47054	-0.151
Philippines	P0	24.848	24.772	-0.308
	P1	6.836	6.794	-0.615
	P2	2.679	2.657	-0.810
Urban	P0	11.570	11.542	-0.243
	P1	2.794	2.777	-0.593
	P2	0.989	0.982	-0.787
Rural	P0	35.584	35.468	-0.325
	P1	10.105	10.042	-0.620
	P2	4.044	4.012	-0.815

Source: Authors' estimates (2017).
P0 - poverty incidence
P1- poverty gap
P2- poverty severity

barriers on rice. The GINI coefficient declines, which may very well indicate that there is an improvement in income equality. All poverty indicators decline as well, which implies a reduction in poverty.

Summary, Policy Insights, and Recommendations

This paper looks at how climate change will affect palay production especially in rainfed (unirrigated) areas in the Philippines. In recent years, the country has experienced wide fluctuations in weather conditions from super typhoons and floods to extended drought in different parts of the country. The production of palay and, consequently, the supply of rice are vulnerable to changes in weather patterns.

Rice is a political commodity as it is highly protected since the 1960s. It is extremely difficult to implement policy reforms in rice because various power groups hinder any policy change. At present, the Philippines is the only remaining WTO-member country that imposes QR on rice. The QR was granted to the Philippines at the time when WTO was established in 1995. Despite after three WTO extensions, the Philippines still retains its QR. As a result to the QR policy, the price that Filipinos pay for rice is more than 80% than the world price. This has a significant implication on poor households because rice is the single largest item in the consumption basket of these household groups.

Using PCGEM, the simulation results indicate that climate change tightens the supply of rice in the domestic market due to the reduction in palay production. This reduction in the supply of rice negatively affects the Philippine economy and worsens poverty as well as income inequality.

Palay production is sensitive to the level of moisture in rice farms. Thus, irrigation is critical in palay production. Chemical inputs (fertilizer) that are needed to increase palay yield cannot be effectively applied if water moisture is not adequate in rice farmlands. Also, high yielding palay varieties are ineffective if irrigation is not enough. While improvements in irrigation (either through new irrigation investments or improvements in existing irrigation facilities) are critical as a mitigating factor to combat the effects of climate change on palay production, it is expensive because it requires a huge investment. Also, the rates of return to irrigation investments is low relative to other forms of investment, which makes it extremely difficult to attract private sector participation. Thus, irrigation requires large government financial resources. This also points out that there are other multifactor variables that can potentially contribute to the improvement in palay and rice production through the improvement of research and development and also public infrastructure.

The paper shows that trade reforms in rice (which do not require financial investments) can be used to minimize the negative impact of climate change on palay production, rice supply and prices, household income, and poverty. The simulation results indicate that reducing both the in-quota and out-quota tariff rates will not only relax the supply constraints in rice supply, it will also lead to overall welfare improvement, higher real income for poor households, and lower poverty and income inequality. However, the policy that the paper suggests stems from the results as the tariff reduction may not necessarily benefit all, as indicated in the results that it favors domestic rice consumers but it disfavors domestic palay and rice producers. One way that the research can further analyze in the future is to identify if agricultural investments, such as irrigation and flood controls, could potentially increase domestic supply of rice. These investments could be cost-reduction for producers and at the same time can further reduce consumer prices in the long-run.

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