Linking Climate Change, Rice Yield and Migration: The Philippine Experience

Flordeliza H. Bordey, Cheryll C. Launio, Eduardo Jimmy P. Quilang, Charis Mae A. Tolentino and Nimfa B. Ogena

WorldFish

Published by WorldFish (ICLARM) - Economy and Environment Program for Southeast Asia (EEPSEA)
EEPSEA Philippines Office, WorldFish Philippines Country Office, SEARCA bldg., College, Los Baños,
Laguna 4031 Philippines; Tel: +63 49 536 2290 loc. 196; Fax: +63 49 501 7493; Email: admin@eepsea.net

EEPSEA Research Reports are the outputs of research projects supported by the Economy and Environment Program for Southeast Asia. All have been peer reviewed and edited. In some cases, longer versions may be obtained from the author(s). The key findings of most *EEPSEA Research Reports* are condensed into *EEPSEA Policy Briefs*, which are available for download at www.eepsea.net. EEPSEA also publishes the *EEPSEA Practitioners Series*, case books, special papers that focus on research methodology, and issue papers.

ISBN: 978-971-9994-17-6

Front cover photo credit: Flordeliza Bordey (main), www.pinoy-ofw.com (top)

Linking Climate Change, Rice Yield and Migration: The Philippine Experience

Flordeliza H. Bordey
Cheryll C. Launio
Eduardo Jimmy P. Quilang
Charis Mae A. Tolentino
Nimfa B. Ogena

March, 2013

Comments should be sent to:
Dr. Flordeliza. H. Bordey, Philippine Rice Research Institute, Maligaya,
Science City of Munoz, Nueva Ecija, Philippines
Tel: 63 44 4560258 loc. 226
Fax: 63 44 4560394 loc. 514
Email: fhbordey@email.philrice.gov.ph

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach that involves attendance in courses and meetings, technical support, access to literature, and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Myanmar, and Papua New Guinea.

EEPSEA is supported by the International Development Research Centre (IDRC) and the Swedish International Development Cooperation Agency (Sida). WorldFish (ICLARM) of the CGIAR consortium has been administering EEPSEA since November 2012.

EEPSEA publications are also available online at http://www.eepsea.net.

ACKNOWLEDGEMENTS

We sincerely express our gratefulness to the Economy and Environment Program for Southeast Asia which funded this study and to the Philippine Rice Research Institute for allowing us to undertake it. We are also grateful to the Philippine Atmospheric Geophysical Astronomical Services Administration (PAGASA) for sharing with us their weather data on selected sites in the Philippines. We also thank Ms. Charis Mae A. Tolentino whose assistance to this research has been invaluable. Finally, our utmost gratitude is due to Dr. Jeff Vincent whose research guidance helped us tremendously in completing this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LINKING CLIMATE CHANGE, RICE YIELD, AND MIGRATION: THE PHILIPPINE EXPERIENCE

Flordeliza H. Bordey,
Cheryll C. Launio,
Eduardo Jimmy P. Quilang,
Charis Mae A. Tolentino
and Nimfa B. Ogena

EXECUTIVE SUMMARY

This study tests the hypothesis that climate change, through its rice productivity impacts, induces out-migration in the Philippines. Results show that climate change effects such as increasing night time temperature and extreme rainfall pattern, by way of reduction in rice yield and farm revenues, significantly increases the number of Overseas Filipino Workers. Findings also show that overseas migration of female workers is more sensitive to climate and rice productivity changes compared to male overseas migration. However, unlike overseas migration, the reduction in yield and farm revenues act as a constraint to domestic migration.

1.0 INTRODUCTION

1.1 Research Problem

Climate change is now globally recognized as one of the most pressing environmental issues of the 21st century that can significantly impact all aspects of life. According to the successive reports of the Intergovernmental Panel on Climate Change (IPCC 1990, 2007), climate has changed over the past century and is expected to continue changing in the future. The Fourth Assessment Report of IPCC projected further increase in atmospheric temperature, rising sea level, disappearance of arctic summer sea ice, and likely occurrences of heat waves and intense tropical storms in the 21st century. These can lead to: increased risk of extinction of 20-30% of all plant and animal species; reduced availability of water supplied by melted glaciers and snow cover; large regional variability in crop yield changes; and decline in agricultural output in rainfed areas (IPCC 2007). These events can affect human lives—their means of livelihood due to loss of habitable areas, increased food insecurity, and reduced access to drinking water. Unfortunately, the impacts of climate change have more severe effects on the developing world where adaptive capacity is wanting.

The Philippines is one of the most vulnerable countries in Southeast Asia (Yusuf and Francisco 2009). Unlike other countries in the region, the Philippines is exposed to multiple hazards such as tropical cyclones, floods, landslides, and droughts. These natural hazards affect agricultural output. Since 34% of the country's labor force is involved in agriculture, the livelihood of a large share of the population is at risk due to climate changes.

In particular, rice is one of the crops that can be extremely affected by changing weather patterns brought about by climate change. Rice growth and production are affected by extreme weather events such as warmer nights, more rainy days, and prolonged period of drought (Centeno and Wassmann 2010). These extreme weather events can cause spikelet sterility, flower abortion, higher transpiration, leaf folding, root rotting, less energy for photosynthesis, submerged crop stand, and higher incidence of pests and diseases—these all lead to lower yield. In addition, flood and drought can cause reduction in area harvested of rice. Since rice contributes 28% of agriculture's gross value added, policymakers must be provided with information about the extent of the impacts of climate change on the rice sector.

Aside from measuring the direct impacts of climate change in rice productivity, it is also useful to learn the farmers' strategy in coping with the changes in their rice income. Migration, whether international or domestic, is an important livelihood strategy of Filipinos. Since the government has been encouraging overseas work, the Philippines has become one of the major sources of migrant workers in the world (Semyonov and Gorodzeisky 2002). According to Quisumbing and McNiven (2005), 26% and 13% of urban and rural households received remittances from migrant parents or children, respectively. As of 2009, there are 1.91 million Overseas Filipino Workers (OFWs) whose remittances reach a total of US$17.45 billion. Domestic migration is also significant in the Philippines. The 2009 Family Income and Expenditure Survey indicated that domestic remittances constitute 3% of the total family income. It will be valuable to learn if change in rice productivity, as driven by climate change, will lead to a change in migration behavior of the farming sector. This information can guide policymakers in designing mechanisms to adapt to climate change.

1.2 Research Objectives

In this study, the impact of change in rice productivity, which is driven by climate change, on international and domestic migration in the Philippines was determined. Specifically, this study:

1. Measured and compared the responses of international and domestic migration to changes in rice productivity induced by climate change;
2. Determined if climate change affects migration of women more than men; and
3. Determined the possible migration scenario under climate change.

2.0 LITERATURE REVIEW

2.1 Climate Change and Rice Productivity

The Second Assessment Report of IPCC (1995) indicated that climate change will significantly affect crop productivity but effects will vary considerably across different locations. In particular, productivity was projected to decrease in the tropics and subtropics. The IPCC estimated that rice yield can decrease to as low as 22% or increase to as high as 28%. This was derived by using the general circulation model of climate change at doubled equivalent CO_2 equilibrium conditions based on data from Bangladesh, India, the Philippines, Thailand, and Indonesia.

In the Philippines, Peng, et al. (2004) found that higher night temperature from global warming had diminished rice yields. Using irrigated field experiment data from 1992 to 2003, grain yield declined by 10% per centigrade increase in the minimum temperature during the dry season. However, maximum temperature was found to have no significant effect on rice yield These results were supported by a rice crop simulation study using Decision Support System for Agrotechnology Transfer or DSSAT crop model (Lansigan 2010). Crop modeling has shown that the probability of rice yield exceeding a certain level is lower under warmer climate condition. This is expected since warmer nights lead to increased maintenance respiration resulting in lower yield.

A similar case in India was established by Auffhammer, Ramanathan, and Vincent (2006) where a 1% increase in minimum temperature during October to November led to 0.87% decline in rice yield. Meanwhile, a 1% increase in rainfall during June to September led to 0.32% increase in rice yield. All these evidences imply that the impacts of climate change on rice yield are real and have already happened.

2.2 Climate Change and Migration

Several studies have demonstrated that people use migration as an adaptive response to actual and perceived impacts of climate change. Deshingkar and Start (2003) investigated seasonal and circular migration of labor in India and found that labor migration was one of most durable components of the livelihood strategies in the rural areas. One of the key findings show that migration was increasingly opening-up to women especially those from lower castes.

In a case study of migration from Eastern Oklahoma to California in the 1930s, Mcleman and Smit (2006) found that exposure to crop failure due to drought or flood influences the potential for migration. Furthermore, adaptive capacity, such as access to capital, social network, health, and ingenuity of family members was found to differentiate migrants from non-migrants.

Massey, Axinn, and Ghimire (2007) found that measures of environmental deterioration, such as declines in agricultural productivity and land cover predict short-distance migration among lower and non-Hindu castes in Nepal. There was no similar link between environmental degradation and international migration established, as findings were confined in particular castes in Nepal only.

Shrestha and Bhandari (2007), however, reported a positive link between increased environmental insecurity and the likelihood of labor migration in Nepal. In this case, environmental insecurity was measured in terms of access to forest resources. The study provided evidence that labor migration was used as a means of diversifying the earning opportunities of households.

Results of the study by Feng, Krueger, and Oppenheimer (2010) showed that climate change can induce cross-border migration from Mexico to the United States. Specifically, a 10% reduction in crop yields would lead to an addional 2% increase in Mexican emigration. Climate change was predicted to induce emigration of approximately 1.4 to 6.7 million Mexican adults by 2080 as a result of declining agricultural productivity due to climate change.

Although migration is an important phenomemon in the Philippines, empirical evidence that links the country's migration pattern to declining rice productivity due to climate change remained scarce. Moreover, there is limited evidence that declining rice productivity induced by climate change affects women migration more than men. These are the contributions of this study.

3.0 METHODOLOGY

3.1 Estimating Migration Using Panel Data

Following Feng, Krueger and Oppenheimer (2010), a two-stage model that uses variations in climate to explain the variability in rice productivity across regions was estimated. The model was used consequently to explain out-migration. Patterned after the methods used by other studies (Auffhammer, Ramanathan, and Vincent 2006; Deschenes and Greenstone 2007; and Feng, Krueger and Oppenheimer 2010), the fluctuations in weather over time were used to identify the effects of climate change on rice productivity within a region. The rice productivity and migration equations used were specified as follows:

$$A_{it} = d + Zg + f_t + g_i + n_{it} \quad \text{(Equation 1)}$$

$$M_{it} = \alpha + \beta A_{it} + h_t + k_i + \varepsilon_{it} \quad \text{(Equation 2)}$$

where *i* denotes region, *t* denotes year, A_{it} is a rice productivity variable (either rice yield or gross revenue per hectare), **Z** is a vector of weather variables, M_{it} is the number of migrants per thousand population, h_t and f_t are year fixed effects, g_i and k_i are region fixed effects, e_{it} and n_{it} are error terms, and d, **g**, *a* and *b* are the parameters to be estimated. **g** is a vector of parameters that measure the marginal effects of weather variables on rice productivity while *b* gives the marginal effects of rice productivity on migration.

The inclusion of region and year fixed effects, h_t and f_t controls for unobserved effects that are unique to a region or a time period. By inclusion of these, other confounding factors that affect migration in each region for a specific year were accounted for. This model, however, accounts only for short run adaptations and results could not be used to forecast effects of climate change far into the future. Instead, the results can be appropriately used to hindcast migration and rice productivity scenarios if climate change had not occurred in the past.

The rice productivity variable in equation 2 is likely to be endogenous since migration can also affect productivity (e.g., out-migration of skilled farmers can lower rice productivity in a certain region). To address endogeneity, Fixed – Effects Two Stage Least Squares (FE-2SLS) approach was used to estimate equation 2. Weather variables, such as dry and wet seasons minimum temperature, maximum rainfall, total rainfall, share of wetdays in a year, share of irrigated area, and interaction of irrigated area share with total rainfall were used as instruments for the rice productivity variable.

Both international and domestic forms of out-migration were considered as dependent variables in equation 2. Separate equations for male and female international migration were also estimated. The magnitude of female and male migration responses to rice productivity change were compared.

3.2 Projecting Climate Change Impacts on Migration Using Hindcast

The extent of international and domestic migration that were induced by changes in rice productivity due to weather changes since 1995 were estimated. To do this, the calculated changes in weather variables from 1995 to 2009 were plugged in the rice productivity equation to determine how much it changed in the same period. Finally, the change in rice productivity was multiplied by b to measure the induced migration. Mathematically, this is expressed as:

$$\Delta Y_{it} = b \left(\frac{\partial A_{it}}{\partial Z_{it}} \right) \Delta Z_{it} \qquad \text{(Equation 3)}$$

where ΔY_{it} is the change in migration and ΔZ_{it} is the change in weather variables.

3.3 Data and Sources

The out-migration experience and rice productivity in the Philippines were analyzed for the period 1995 to 2009 using data from all rice-producing regions in the country. The changes in regional groupings over the coverage period resulted in an unbalanced panel with 216 observations[1].

Table 1 provides description of the variables used in the regression. The international migration was expressed in terms of number of OFWs per thousand population. The data on the number of OFWs per region was obtained from the Survey of Overseas Filipinos (SOF), which was conducted by the National Statistics Office. The SOF is a rider survey to the October round of the Labor Force Survey every year. This survey collects data on the number of OFWs who are abroad in the last five-year reference period[2]. The population in the last five years (expressed in thousands) was used as the denominator.

[1] The details in regional groupings were listed in Appendix 1.
[2] For more detailed information about the Survey of Overseas Filipinos, see http://www.census.gov.ph/content/technical-notes-survey-overseas-filipinos-sof.

Table 1. Variables used in the migration and rice productivity equations

Variable	Definition
TMIG	Total number of OFWs in the region per 1000 population [OFWs are those who are abroad within the last five-year reference period (i.e., if the reference period is September 1995, the last five-year period refers to October 1991 to September 1995). The population in the last five years ago used as denominator.]
FMIG	Total number of female OFWs in the region per 1000 female population
MMIG	Total number of male OFWs in the region per 1000 male population
RMIG	Total number of domestic out-migrants per 1000 population Σ
MINLS1	Five-year average of lowest recorded temperature during January to June (dry season) based on observations in different weather stations located in the region (°C) (i.e. $MNLS1_{1995} = \sum_{t=1990}^{1994}$ Minimum Temperature t/5)
MINLS2	Five-year average of lowest recorded temperature during July to December (wet season) based on observations in different weather stations located in the region (°C)
MAXRS1	Five-year average of highest recorded daily rainfall during January to June (dry season) as observed in the weather stations per region (mm)
MAXRS2	Five-year average of highest recorded daily rainfall during July to December (wet season) as observed in the weather stations per region (mm)
TRAINS1	Five-year average of cumulative rainfall during January to June (dry season) as observed in the weather stations per region (mm)
TRAINS2	Five-year average of cumulative rainfall during July to December (wet season) as observed in the weather stations per region (mm)
SWET	Share of days with more than 5 mm rainfall in a year (%)
SIA	Share of irrigated area to total area harvested to rice (%)
SIATR	Interaction of SIA to five-year average of cumulative rainfall in a year
YIELD	Five-year average of rice production per unit area (mt/ha)
GRPH	Five year average of yield multiplied by the real price of paddy rice (PhP 1,000/ha)

The domestic migration was expressed in terms of number of domestic out-migrants per thousand population in each region. To derive this data, the out-migration rate per region were calculated from the 2000 Census of Population and Housing using the information on current region of residence and region of residence in the last five years. To estimate the number of domestic out-migrants per region in a particular year, the out-migration rates were multiplied by the average of a specific year population and population in the last five years[3]. Similar to the international migration, the population in the last five years (expressed in thousands) was also used as the denominator.

Rice productivity variables were expressed in terms of five-year averages since migration variables were relevant for the past five years. Data on regional rice production and area harvested were obtained from the *Palay* (paddy rice) and Corn Production Survey of the Bureau of Agricultural Statistics[4]. For each year, production was divided by area harvested to obtain annual yield. The average yield for the past five years was then calculated. To derive a measure of gross revenue per hectare, the annual yield was multiplied by the consumer price index-adjusted price of paddy rice. Then, the five-year average of the gross revenue per hectare was computed.

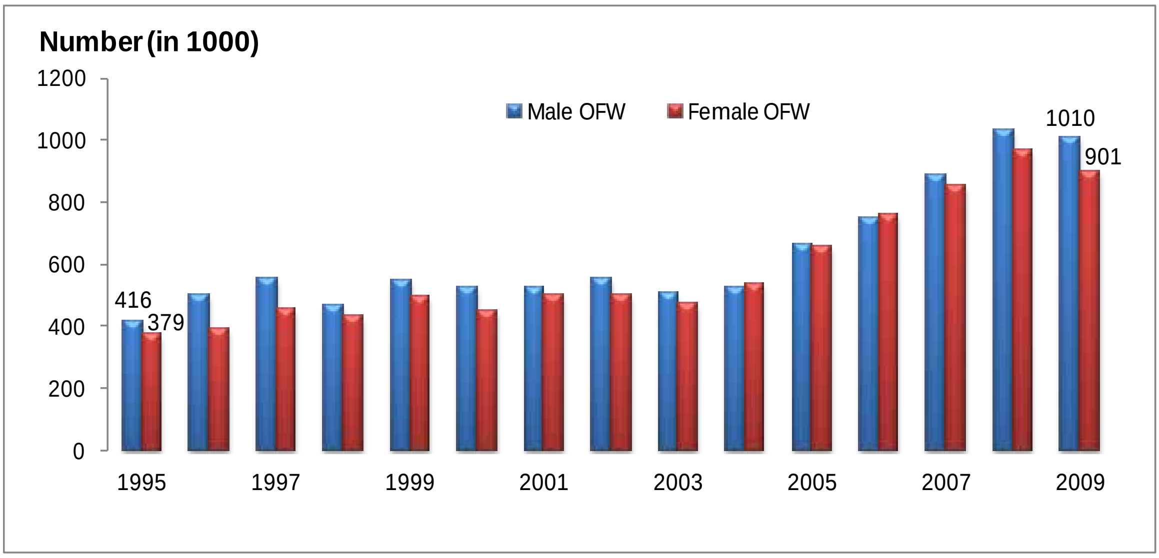
[3] Details of the calculation of the regional out-migration rate are described in Appendix 2.
[4] For more detailed information about the *Palay* and Corn Survey of the BAS, see http://countrystat.bas.gov.ph/?cont=2.

Similarly, weather variables were expressed as five-year averages to suit the time coverage of rice productivity. Weather data in selected agrometeorological stations were acquired from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). The stations were selected based on their proximity to major rice growing areas in each region[5]. Weather variables include daily minimum temperature and rainfall. Using the rainfall data, the five-year average of cumulative rainfall per annum as well as the five-year average of maximum rainfall per year were obtained. The annual number of wetdays, which is defined as days with rainfall greater than 5 mm was calculated. This was used to compute for the five-year average of share of wetdays in a year.

4.0 TRENDS IN PHILIPPINE MIGRATION, RICE PRODUCTION, AND WEATHER PATTERNS

4.1 Overseas Filipino Workers

The estimated number of OFWs rose from 0.80 million in 1995 to 1.912 million in 2009 (Figure 1). In the last 15 years, the share of male OFWs was 52% while female OFWs accounted for 48%. The number of female OFWs increased by an average of 6.4% while male OFWs increased by 5.5% annually. In 2009, about 32% of OFWs were laborers and unskilled workers, 15% were involved in service and market sales, another 15% were involved in trade-related work, and 14% were plant and machine operators and assemblers.

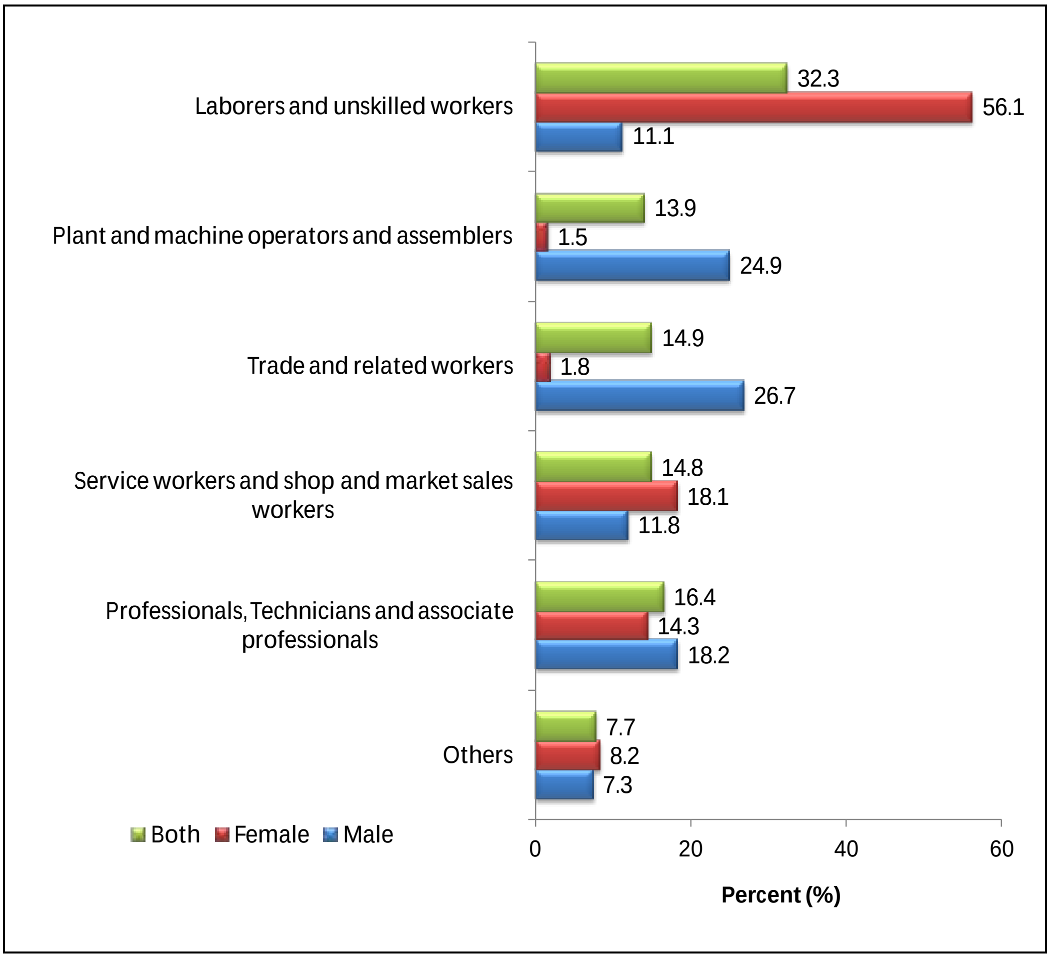


Source of basic data: National Statistics Office

Figure 1. Number of OFWs by sex (1995-2009)

Male OFWs were mostly concentrated in trade-related works (27%) as well as plant and machinery operation and assembly (25%). On the other hand, majority of female OFW were laborers and unskilled workers (56%), who provided housekeeping-related services (Figure 2).

[5] The selected PAGASA stations in each region are listed in Appendix 3.



Source of basic data: National Statistics Office

Figure 2. Distribution of OFWs by sex and major occupation (2009)

Since 1995, majority of OFWs come from the Luzon island excluding the National Capital Region (NCR)[6]. Luzon's share decreased from 60% in 1995 to only 52% in 2009 (Table 2). In contrast, the shares of Visayas and Mindanao increased to 18% and 16%, in the same year, respectively. This implies that the nature of origin of OFW is shifting from urban to rural areas.

Table 2. Distribution of OFWs by major group of islands (1995 and 2009)

Region	1995			2009		
	Both %	Male %	Female %	Both %	Male %	Female %
National Capital Region (NCR)	15	20	9	14	16	11
Luzon (minus NCR)	60	55	65	52	54	50
Visayas	13	14	11	18	19	18
Mindanao	12	11	15	16	11	21

[6] National Capital Region was excluded in the analysis because it is not a rice-producing region.

4.2 Regional Migration

From 1995 to 2009, the average number of domestic out-migrants per region increased by 23% from 65,892 to 80,967. In comparison, the average number of OFWs per region has doubled in the same period, from 50,846 to 106,733. This shows that migration pattern in the Philippines is recently favoring international destinations compared to domestic ones. This is due to more attractive wage compensation abroad. For example, a household helper working abroad can receive as much as PhP 20,000 per month whereas, in a similar nature of work in Metro Manila, he/she can only earn a minimum wage compensation of about PhP 2,500 monthly.

4.3 Trends in Rice Production

The five-year average of rice yield in the Philippines showed an increasing trend from 1995 to 2009 with an annual increase of 63 kg/ha (Figure 3). After stagnating in the late 1990s, faster growth in yield was observed since 2000. This was due to government programs on increasing utilization of high quality seeds including promotion of hybrid rice varieties and investments on irrigation facilities (Bordey 2010). The rise in the share of farmers who have attended rice production-related trainings has also contributed to improved rice yields. From 1995 to 2009, Central Luzon and Central Visayas have the highest and lowest average yields, respectively (BAS 2011).

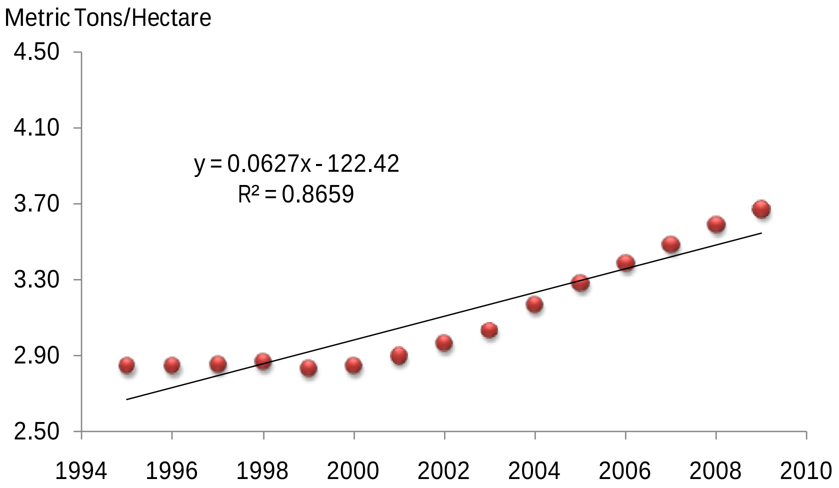


Figure 3. Five-year average rice yield in the Philippines (1995-2009)

The five-year average rice area harvested increased from 3.38 Mha in 1995 to 4.22 Mha in 2009, growing annually by 56,000 ha (Figure 4). Despite near stagnation in physical rice area, the area harvested expanded due to the increase in cropping intensity brought about by public and private investments in irrigation systems. The Casecnan Multi-purpose Irrigation and Power Project that diverts water from Casecnan and Taan river in Cagayan Valley region to Pantabangan dam in Central Luzon is one of the big irrigation projects implemented from 1995 to 2009. As a result, Central Luzon region has the largest area harvested to rice during this period. In contrast, Cordillera Administrative Region (CAR) has the smallest rice harvest area in the same period.

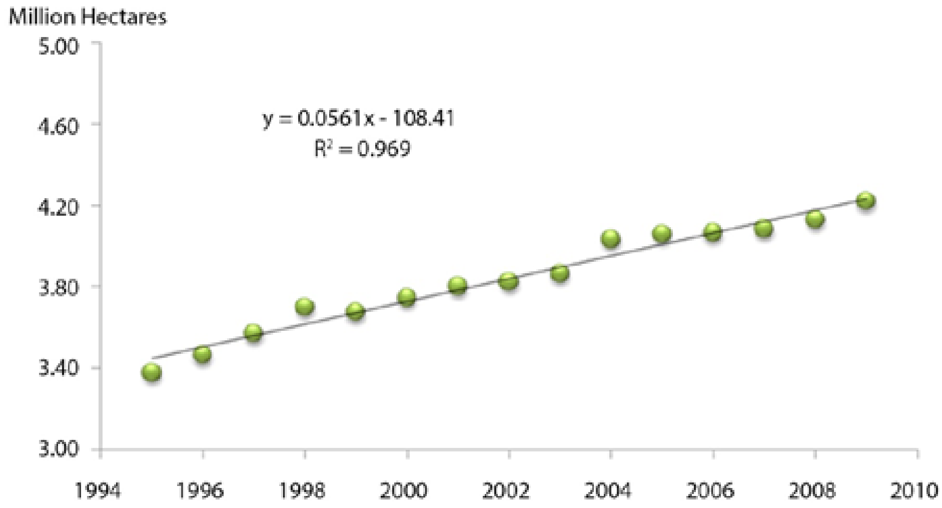


Figure 4. Five-year average rice area harvested in the Philippines (1995-2009)

Because of the improvement in yield and expansion of rice area harvested, the five-year average paddy rice production in the Philippines increased annually by 0.42 million metric tons (Mmt) from 9.62 Mmt to 15.50 Mmt (Figure 5). The apparent slowdown in production growth in the early 2000s was brought about by the El Nino phenomenon in 1998.

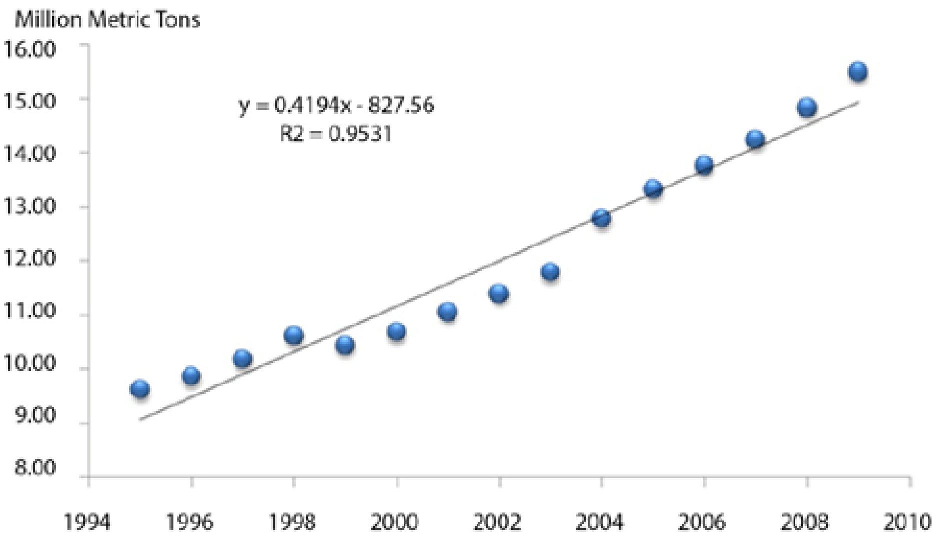


Figure 5. Five-year average of paddy rice production in the Philippines (1995-2009)

The five-year average of the value of paddy rice production at the national and regional level increased by 59% and 38% from 1995 to 2009, respectively (Table 3). The less than proportionate increase in value compared to increase in production level was due to the decreasing real farmgate price of paddy rice. In the same period, the five-year averages of national and regional gross revenue per hectare both increased by 27%.

Table 3. Five-year averages of value of paddy rice production and gross income per hectare (1995 and 2009)

Particulars	1995	2009	Percent Change
National Five-Year Average			
Production (metric tons)	9,618,748	15,496,447	61.11
Value of Production (PhP billion)	86.83	137.95	58.87
Gross Revenue per Hectare (PhP/hectare)	25,742	32,683	26.96
Regional Five-Year Average			
Production (metric tons)	706,932	995,258	40.79
Value of Production (PhP billion)	6.45	8.91	38.13
Gross Revenue per Hectare (PhP/hectare)	25,267	32,152	27.25

4.4 Weather Patterns

Weather patterns in the Philippines have changed in the last 15 years (Table 4). In particular, the five-year average of minimum or night time temperature in the first and second semesters of the year have both increased by nearly 1^{O}C. This is consistent with the findings of PAGASA (2011) which indicated a 1^{O}C increase in the annual mean of minimum temperature from 1951 to 2010.

Table 4. Five-year averages of weather variables in the Philippines (1995 and 2009)

Particulars	1995	2009	Change
Minimum Temperature (^{O}C)			
January-June (Semester 1)	18.12	19.05	0.93
July-December (Semester 2)	18.91	19.73	0.82
Maximum Rainfall (mm)			
January-June (Semester 1)	109	127	18
July-December (Semester 2)	156	169	13
Total Rainfall (mm)			
January-June (Semester 1)	640	927	287
July-December (Semester 2)	1381	1553	172
Share of Wet days in a Year (%)	23.00	26.80	3.80

The first semester of the year, which coincides with the dry season, has become wetter as indicated by bigger changes in daily maximum and cumulative rainfall. The second semester, which represents the wet season, has also become wetter over the years although, the magnitude of change is lower compared to that of the first semester. This is accounted for by the 4.0 percentage points increase in the share of wetdays in a year.

5.0 RESULTS AND DISCUSSIONS

5.1 Impacts of Climate Change on Rice Productivity

Table 5 summarizes the estimates of the rice productivity equation. Two models were estimated for both equations of rice yield and gross revenue per hectare. Models 1 and 3 contained all weather variables, while models 2 and 4 did not include the share of irrigated area and its interaction with rainfall. The R^2 values in all models are high (≈0.89) indicating a good fit of the estimated models. The F-statistics also show that coefficients of all weather variables are significant in each rice productivity model.

Table 5. Regression results of rice productivity on weather variables

Explanatory Variables	Dependent Variable			
	Yield		Gross Revenue per Hectare	
	Model 1	Model 2	Model 3	Model 4
Minimum Temperature (Semester 1)	0.60635**	0.58207**	3.02425	2.30944
Minimum Temperature (Semester 1)^2	-0.01783**	-0.01744**	-0.0852	-0.06846
Minimum Temperature (Semester 2)	-0.55581	-0.61072	-3.25016	-2.99011
Minimum Temperature (Semester 2)^2	0.01646	0.01788	0.08938	0.08427
Maximum Rainfall (Semester 1)	-0.00034	-0.00021	-0.01925	-0.03182
Maximum Rainfall (Semester 1)^2	0.00001	0.00001	0.0001	0.00013
Maximum Rainfall (Semester 2)	0.00036	-0.00043	0.00214	0.00036
Maximum Rainfall (Semester 2)^2	0.00000	0.00000	-0.00002	-0.00002
Total Rainfall (Semester 1)	0.0001	-0.00013	0.00192	-0.00136
Total Rainfall (Semester 1)^2	0.00000	0.00000	0.00000	0.00000
Total Rainfall (Semester 2)	0.00074	0.00059	0.01077**	0.00598
Total Rainfall (Semester 2)^2	0.00000	0.00000	0.00000	0.00000
Share of Wet Days	-0.03844***	-0.03570***	-0.36598***	-0.35588***
Share of Irrigated Area	-0.21337		17.93986*	
Share of Irrigated Area x Total Rainfall	-0.00029		-0.0068	
Constant	2.69415	3.39667	19.58266	36.05072*
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
F-Statistic (Joint Significance Test of All Weather Variables)	22.27***	26.78***	18.63***	11.62***
R-squared	0.889	0.885	0.894	0.887
Number of regcode	20	20	20	20
Observations	216	216	216	216

Note: Significance based on robust p-values, *** p<0.01, ** p<0.05, * p<0.1

To interpret the estimated coefficients, the simpler models 2 and 4 of yield and gross revenue per hectare equations were used[7]. As expected, the minimum temperature during the dry season has a negative effect on the average rice yield. In particular, a 1°C increase in minimum temperature during summer decreases yield by 64 kg/ha[8]. Higher minimum temperature increases the respiration rate and uses

[7] Other insignificant weather variables were excluded in the model but results did not change much (see Appendix 4).

[8] This is computed as: $\partial Yield/\partial Minls1 = \gamma_{Minls1} + 2(\gamma_{Minls1}2)(Mean\ Minls1) = 0.58207 + 2(-0.01744)(18.52)$

energy that could be potentially used for plant growth. This results in reduced tillers per plant, lower plant height and biomass, and greater number of unfilled grains leading to a decline in yield (Ziska et al. 1997).

Similarly, rice yield diminishes by 36 kg/ha for every 1% increase in the share of wetdays. This is in relation to lower solar radiation during wetdays which results in lower energy for photosynthetic activity (Centeno and Wassmann 2010). The average gross income per hectare also has a negative correlation to the increase in the share of wetdays. On average, a 1% increase in the share of wetdays decreases farm income by Php 356.00 per hectare[9].

5.2 Impacts of Rice Productivity Change on Overseas Migration

Table 6 shows the result of the second stage of the FE-2SLS estimation of the migration equation. With R^2 value of 0.94, all models show a high goodness of fit. In addition, all models also passed the underidentification test as indicated by the significant Kleibergen-Paap rk LM statistics at 99% confidence level.

However, only models 2 and 4 have passed the overidentification test. The insignificant Hansen J statistics imply that the estimated coefficients of these models are free of biases arising from use of weak instruments.

Table 6. Regression results of the number of total OFWs per thousand population on rice productivity variables

Explanatory Variables	Dependent Variable: Total OFWs/1000 Population			
	Yield		Gross Revenue per Hectare	
	Model 1	Model 2	Model 3	Model 4
Yield	-4.76570**	-6.24139***		
	[0.03302]	[0.00696]		
Gross Revenue per Hectare			-0.72369**	-0.92964***
			[0.01985]	[0.00410]
Constant	17.36179***	20.72297***	19.80468***	23.58906***
	[0.00073]	[0.00009]	[0.00062]	[0.00008]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	43.06***	37.95***	40.06***	36.48***
Hansen J statistic	24.77**	17.90	21.41*	15.00
R-squared	0.939	0.937	0.938	0.936
Observations	216	216	216	216

Note: Robust p-values in brackets; *** p<0.01, ** p<0.05, * p<0.1

Results show that changes in rice yield and gross revenue per hectare due to extreme weather changes significantly affect overseas migration. In particular, the number of total OFW by increased by five persons per thousand population for every one metric tonne decrease in average yield. Similarly, the number of total OFW rose by one person per thousand population for every PhP 1,000 decline in the average gross revenue per hectare .

The estimated models of female overseas migration also show high R^2 value of 0.94. The significant Kleibergen-Paap rk LM statistics at 99% confidence level indicates that all female migration models are not underidentified. Except for model 1, all other models have an insignificant Hansen J statistics implying that these models are not overidentified. Based on the results of model 2, the number of female OFWs increased by seven per thousand female population when a one metric tonne decrease in average yield was observed (Table 7). Likewise, one female OFW per thousand population migrated-out for every PhP 1,000 decline in gross revenue per hectare.

[9] The average peso-dollar exchange rate in 2011 is PhP43.31/US$. Source: http://ricestat.irri.org.

Table 7. Regression results of the number of female OFWs per thousand female population on rice productivity variables

Explanatory Variables	Dependent Variable: Female OFWs/1000 Female Population			
	Yield		Gross Revenue per Hectare	
	Model 1	Model 2	Model 3	Model 4
Yield	-5.49324**	-7.09157**		
	[0.04388]	[0.01525]		
Gross Revenue per Hectare			-1.17834***	-1.09822**
			[0.00414]	[0.01017]
Constant	18.52544***	22.16599***	27.66546***	26.19316***
	[0.00327]	[0.00085]	[0.00035]	[0.00106]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	43.06***	37.95***	40.06***	36.48***
Hansen J statistic	25.69**	11.75	15.66	9.35
R-squared	0.937	0.936	0.936	0.937
Observations	216	216	216	216

Note: Robust p-values in brackets; *** p<0.01, ** p<0.05, * p<0.1

Table 8 shows the results of estimating male overseas migration. The male migration models also indicate high R^2 value of 0.92 and Kleibergen-Paap rk LM statistics show that these models are not underidentified. Only model 4 has an insignificant Hansen J statistics at confidence level of 95% implying that it is the only model of male migration that is not overidentified.

The coefficient of gross revenue per hectare, as instrumented by weather variables, is not significant at 95% confidence level. This provides evidence that compared to overseas migration of male workers, the female overseas migration is more affected by weather-related decline in rice productivity.

Table 8. Regression results of the number of male OFWs per thousand male population on rice productivity variables

Explanatory Variables	Dependent Variable: Male OFWs/1000 Male Population			
	Yield		Gross Revenue per Hectare	
	Model 1	Model 2	Model 3	Model 4
Yield	-4.11519	-5.38409*		
	[0.16247]	[0.07067]		
Gross Revenue per Hectare			-0.24743	-0.73932*
			[0.50817]	[0.05963]
Constant	16.32150**	19.21168***	11.49486*	20.53326***
	[0.01579]	[0.00542]	[0.09761]	[0.00472]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	43.06***	37.95***	40.06***	36.48***
Hansen J statistic	30.28***	23.36**	31.86***	20.58*
R-squared	0.922	0.92	0.922	0.917
Observations	216	216	216	216

Note: Robust p-values in brackets; *** p<0.01, ** p<0.05, * p<0.1

The result can be driven by a large proportion of female OFWs who were involved in unskilled work, such as housekeeping services. There is greater probability that many of these unskilled female OFWs come from rural areas and were somehow involved in farming activities in the past. On the contrary, a greater proportion of male OFWs were involved in trade-related services as well as plant and machinery operations.

With higher level of skills, it is less likely that male OFWs were mainly involved in farming activities prior to migration. This could explain why climate change, as it operates on productivity change, has greater impact on overseas migration of women than men in the Philippines.

This result on women migration is consistent with the findings of some case studies on gender and migration in the Philippines. McKay (2005) found that women usually worked as exchange and household labor for planting and harvesting (non-waged), and were involved in unpaid activities, such as weeding. Given a negligible opportunity cost, women are enticed to work abroad to get higher value for their labor while their male counterparts continue farming.

5.3 Impacts of Rice Productivity Change on Domestic Migration

Table 9 shows the effect of weather-induced change in rice productivity on domestic regional migration. At 0.98 level of R^2, the estimated models of domestic migration show a very good fit. Similarly, based on Kleibergen-Paap rk LM statistics at 99% confidence level, all domestic migration models are not underidentified. However, only model 4 is not overidentified at 95% level of confidence. Using model 4, the number of domestic (inter-regional) migrants decreased by less than one person per thousand population for every PhP 1,000 decrease in average gross income per hectare. Thus, contrary to the observed effects in overseas migration, a decline in rice productivity could actually reduce domestic migration. However, this result should be further verified when panel data on inter-regional migration rates becomes available.

Table 9. Regression results of the number of domestic regional migrants per thousand population on rice productivity variables

Explanatory Variables	Dependent Variable: Domestic Migrants/1000 Population			
	Yield		Gross Revenue per Hectare	
	Model 1	Model 2	Model 3	Model 4
Yield	2.05493***	1.75133***		
	[0.00077]	[0.00022]		
Gross Revenue per Hectare			0.18353**	0.17539***
			[0.01853]	[0.00294]
Constant	19.54413***	20.23564***	20.85227***	21.00194***
	[0.00000]	[0.00000]	[0.00000]	[0.00000]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	43.06***	37.95***	40.06***	36.48***
Hansen J statistic	23.95**	22.07**	25.82**	20.80*
R-squared	0.98	0.981	0.979	0.979
Observations	216	216	216	216

Note: Robust p-values in brackets; *** p<0.01, ** p<0.05, * p<0.1

There is a seeming paradox on the effects of weather-related change in rice productivity on overseas and domestic migration. Why would Filipino households send a member to work overseas rather than in other regions of the country when rice yield or revenue decline due to weather changes? It is very likely that the nature of farming households sending members to work abroad are different from those that send members to local regions. The former could have more access to resources like land. Given larger expected returns from overseas work compared to work in other local regions, a relatively wealthier farming household can pool resources to send a member abroad, thereby diversify its sources of livelihood. It is a usual scenario in the Philippines when a farming household pawns its land to raise the needed resources to send a member overseas to work. Consequently, remittances from abroad are used to regain access to the pawned land.

On the other hand, farming households that send out members locally are the relatively poorer ones. Thus, a decline in rice yield or gross revenue may act as constraint from sending members to other regions within the country. Figure 6 demonstrates that on average, regions with larger per capita rice harvest area and value of rice production have more OFWs and have less domestic out-migrants.

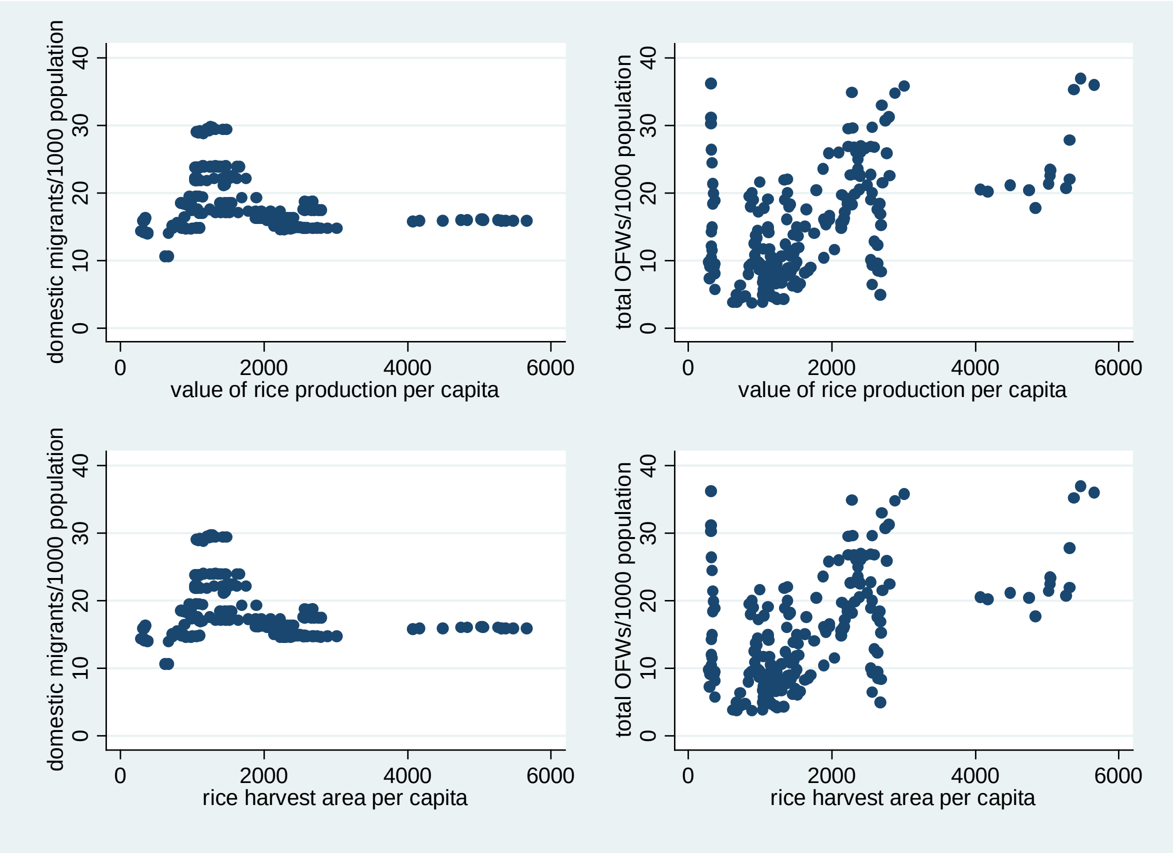


Figure 6. Domestic migrants and total OFWs per 1000 population versus per capita rice harvest area and value of rice production

5.4 A Hindcast of Climate Change Impacts on Migration

The significant coefficients of minimum temperature during January to June and share of wetdays in a year were used to project the impact of climate change on rice yield from 1995 to 2009. During this period, the dry season minimum temperature has increased by 0.93 ºC leading to a 60 kg/ha decline in five-year average of rice yield. Similarly, the share of wet days in a year has risen by 3.8 percentage points translating into 136 kg/ha decrease in yield. Given the combined effect of 195 kg/ha decline in yield and at a national average of 3.8 million hectares of rice harvest area, this means that the country lost about 742,000 mt from 1995 to 2009 due to the increases in dry season minimum temperature and share of wetdays in a year. At the national level, this translates to almost 99,000 individuals who migrated overseas to find work, among whom are 57% female.

Similarly, the 3.8% points increase in the share of wet days from 1995 to 2009 translates in a reduction in gross revenue by PhP 1,352 per hectare. Multiplying it by the national average of rice harvest area of 3.8 million hectares, this translates to PhP 5.14 billion revenue loss in the last 15 years. Further, projection shows that about 102,000 OFWs were induced to work abroad by climate change as it operates through a decline in rice gross revenue per hectare. In addition, about 19,000 individuals were not able to migrate inter-regionally due to the reduced rice gross revenue per hectare, as affected by increased share of wetdays in a year.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Evidence was found that climate change, which caused reduction in rice productivity, has induced overseas migration of Filipinos in the last 15 years. In addition, overseas migration of women are more affected than those of men. For households that have access to resources for start-up cost, overseas migration could have been used as a strategy to diversify income and adapt to the negative effects of climate change on rice yield and revenues. Thus, with climate expected to be warmer and wetter in the succeeding decades, it is expected that migration of overseas workers will intensify.

As the number of overseas migrants from rural areas increases, remittances are expected to flow back in these areas. This could potentially revolutionize the agricultural financing system in the rural areas. The increase in liquidity can provide the capital needed to adopt new technologies, counter the negative effects of climate change, and improve rice productivity in the long run. Thus, it is important to keep information on the latest rice technologies flowing into rural areas as well as into OFWs who act as financiers. The use of information and communication technologies such as the Internet and short messaging service (SMS) can help in this aspect. Opportunely, the Philippines has already established electronic learning modules for rice production and put up SMS centers intended for rice farmers.

Unfortunately, overseas migration has a huge social cost despite its economic benefits. For instance, the Office of the Solicitor General reported that the number of marriage annulment cases filed in the Philippines has increased by 40% from 2004 to 2010. While this cannot be attributed to the increase in overseas migration alone, the latter might have contributed to increasing cases of marriage dissolution. In addition, overseas migration can negatively affect children's growth especially when mothers have to work overseas. These imply that society has to to endure the social burden of higher migration of women.

To address this, the government can intensify its social services in the form of providing early childhood care and education especially in the rural areas. Currently, the Republic Act 8980 of 2000 mandates the institutionalization of a comprehensive, integrated, and sustainable National System for Early Childhood Care and Development. However, there are a few early childhood care centers established in rural areas compared to urban areas. In addition, the present curiculum for early childhood care and education does not fully consider cases of migrant parents. Even the basic elementary education system in the country does not take into account the reality that there is an increasing number of children who are growing with absentee parents. With migration becoming the norm rather than the exception, increasing the number of day-care centers in the rural areas as well as improving the curicula of early childhood and basic education could help in easing the social burden of migration.

It was also found that weather-related decline in rice productivity can reduce the number of domestic migrants. If the affected households are in fact the relatively poorer ones, then these people will become more income vulnerable and food insecure since they have lesser opportunities to diversify their income. Given the availability of household labor, these type of households are good target for training on rice-based farming systems. Crop diversification will lessen their vulnerability to productivity losses due to climate change.

Finally, research and development (R&D) provides technology options that can offset the negative effects of climate change on rice yield and income. Thus, it will be important to intensify rice R&D as well as the promotion of its products so that there will be greater adoption of technology. This will somehow help mitigate the impacts of climate change on rice productivity and migration.

REFERENCES

Aufhammer, M.; V. Ramanathan; and J. Vincent. 2006. Integrated models show that atmospheric brown clouds and greenhouse gases have reduced rice yields in India. http://www.pnas.org_cgi_doi_10.1073_pnas.0609584104.

Bardsley, D.K. and G.J. Hugo. 2010. Migration and climate change: examining thresholds of change to guide effective adaptation decision-making. Population Environment. Vol. 32, pp. 238-262.

Bureau of Agricultural Statistics. http://countrystat.bas.gov.ph (accessed on January 5, 2011)

Bordey, F.H. 2010. The impacts of research on Philippine Rice Production. University of Illinois. PhD dissertation.,

Centeno, H.G.S., and R. Wassmann. 2010. Reviewing impacts of climate change and climate variability on rice production in the Philippines. In Adaptation to climate change and variability. Lansigan, F.P. (ed). Asia Rice Foundation, College, Laguna, Philippines. pp. 1-20.

Deschenes, O., and M. Greenstone. 2007. The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. American Economic Review 97(1):354-385.

Deshingkar, P., and D. Start. 2003. Seasonal migration for livelihoods in India: coping, accumulation and exclusion. Overseas Development Institute, London. Working paper 220.

Feng, S.; A.B. Krueger; and M. Oppenheimer. 2010. Linkages among climate change, crop yields and Mexico-US cross-border migration. http://www.pnas.org/cgi/doi/10.1073/pnas.1002632107.

First Assessment Report. 1990. Intergovernmental Panel on Climate Change. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml .

Fourth Assessment Report. 2007. Intergovernmental Panel on Climate Change. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

Kolmannskog, V. 2009. Climate change, disaster, displacement and migration: initial evidence from Africa. Policy Development and Evaluation Service, United Nations High Commissioner for Refugees. Research Paper No 180..

Lansigan, F.P. 2010. Responding to changing climate in rice production in the Philippines." In ." In Adaptation to climate change and variability. Asia Rice Foundation, College, Laguna, Philippines. pp. 21-46

Massey, D.S.; W.G. Maxinn; and D.J. Ghimire. 2010. Environmental change and out-migration: evidence from Nepal. Population and Environment, Vol. 32, pp. 109-136.

McLeman, R. and B. Smit. 2006. Migration as adaptation to climate change. Climatic Change, Vol. 76, pp. 31-53.

McKay, D. 2005. Reading remittance landscapes: Female migration and agricultural transition in the Philippines. Danish Journal of Geography 105(1):89-99.

National Framework Strategy on Climate Change 2010-2022. Office of the President of the Philippines, Malacañang. Climate Change Commission, pp 9-11.

PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration). 2011. Climate Change in the Philippines. Quezon City, Philippines.

Peng, S.B.; J.L. Huang; J.E. Sheehy; R.C. Laza; R.M. Visperas; X.H. Zhong; G.S. Centeno; G. S. Khush; and K.G. Cassman. 2004. Rice yields decline with higher night temperature from global warming. http://www.pnas.org/content/101/27/9971.short

Quisumbing, A.R. and S. McNiven. 2005. Migration and the rural-urban continuum: evidence from the rural Philippines. Food Consumption and Nutrition Division, International Food Policy Research Institute, Washington DC.

Raleigh C.; L. Jordan; and I. Salehyan. 2008. Assessing the impact of climate change on migration and conflict. The Social Development Department. The World Bank Group, Washington, DC.

Second Assessment Report. 1995. Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf

Semyonov M., and A. Gorodzeisky. 2004. Occupational destinations and economic mobility of Filipino overseas workers. International Migration Review, Vol. 38, Issue 1, March 2004, pp.5-25.

University of Adelaide, et al. 2009. Climate change and migration in Asia and the Pacific. Asian Development Bank, Mandaluyong City. Philippines.

Yusuf, A.A., and H. A. Francisco. 2009. Climate change vulnerability mapping for Southeast Asia. Economy and Environment Program for Southeast Asia.

Ziska, L.H.; O.S. Namuco; T. B. Moya; and E.J.P. Quilang. 1997. Growth and yield response of field grown tropical rice to increasing carbon dioxide and air temperature. Agronomy Journal 89:45-53.

APPENDICES

Appendix 1. Regional groupings of provinces in the Philippines, 1995-2009

REGION	ABBREVIATION	YEAR	PROVINCES
Cordillera Administrative Region	CAR	1995-2009	Benguet, Kalinga, Apayao, Abra, Ifugao, Mountain Province
Ilocos Region	ILOCOS	1995-2009	Ilocos Norte, Ilocos Sur, Pangasinan, La Union
Cagayan Valley	CVALLEY	1995-2009	Isabela, Nueva Vizcaya, Cagayan, Quirino, Batanes
Central Luzon	CLUZON1	1995-2002	Bataan, Bulacan, Nueva Ecija, Pampanga, Zambales, Tarlac
Central Luzon	CLUZON2	2003-2009	Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Zambales, Tarlac
Southern Tagalog	STAGALOG	1995-2002	Aurora, Cavite, Laguna, Batangas, Rizal, Quezon, Occidental Mindoro, Oriental Mindoro, Marinduque, Romblon, Palawan
Region IV-A	CALABARZON	2003-2009	Cavite, Laguna, Batangas, Rizal, Quezon
Region IV-B	MIMAROPA	2003-2009	Occidental Mindoro, Oriental Mindoro, Marinduque, Romblon, Palawan
Bicol Region	BICOL	1995-2009	Albay, Camarines Norte, Camarines Sur, Masbate, Sorsogon
Western Visayas	WVISAYAS	1995-2009	Aklan, Guimaras, Iloilo, Negros Occidental, Capiz, Antique
Central Visayas	CVISAYAS	1995-2009	Cebu, Negros Oriental, Bohol, Siquijor
Eastern Visayas	EVISAYAS	1995-2009	Biliran, Eastern Samar, Leyte, Northern Samar, Samar, Southern Leyte
Western Mindanao	WMINDANAO	1995-2009	Zamboanga del Norte, Zamboanga del Sur, Zamboanga Sibugay
Northern Mindanao	NMINDANAO1	1995-2002	Bukidnon, Camiguin, Misamis Occidental, Misamis Oriental
Northern Mindanao	NMINDANAO2	2003-2009	Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental, Misamis Oriental
Central Mindanao	CMINDANAO	1995-2001	Lanao del Norte, North Cotabato
Southern Mindanao	SMINDANAO	1995-2001	Davao City, Davao del Norte, Davao Oriental, Davao del Sur, Sarangani, South Cotabato, Sultan Kudarat, (General Santos City – part of South Cotabato during this period. It was not considered as an autonomous city before the creation of SOCCSKSARGEN in 2001)
Davao Region	DAVAO	2002-2009	Davao City, Davao del Norte, Davao Oriental, Davao del Sur
SOCCSKSARGEN	SOCCSKSARGEN	2002-2009	South Cotabato, North Cotabato, Sultan Kudarat, Sarangani, General Santos
CARAGA	CARAGA	1996-2009	Agusan del Norte, Agusan del Sur, Surigao del Norte, Surigao del Sur

Appendix 2. Deriving measures of domestic migration

Regional out-migration rates were derived from two variables, i.e., current region of residence and region of residence 5 years before the 2000 Census of Population and Housing. To account for the changing classification of provinces by region from 1995 to 2009, the regions were reconstructed using the 2000 census data as basis for the setting up of three matrices of regions of origin and destination. The three time periods used for the matrices are 1995-2001, 2002 and 2003-2009.

Initially, unclassifiable responses (i.e., unknown and other places) in the previous residence variable were prorated based on the distribution of responses by pertinent regions in the above-cited three time periods. The table below shows the descriptive statistics of the unclassifiable responses that were prorated.

Appendix 2.1. Summary statistics of unclassified responses

Regional classification in	Mean	Standard Deviation
1995-2001	2.68	1.163
2002	2.66	1.154
2003-2009	2.67	1.123

The out-migration rate (OMR) expresses the number of people moving out of a region for the purpose of changing permanent residence per 1,000 population during the time period t-5 to t.

$$\text{Out-migration rate} = \frac{\text{Number of out-migrants from a region x 1000}}{0.5(\text{Population}_t + \text{Population}_{t-5})}$$

Appendix 2.2. Estimated regional out-migration rates:

REGIONAL CLASSIFICATION	Out-migration rate		
	1995-2001	2002	2003-2009
Ilocos Region	1.400	1.400	1.401
Cagayan Valley	1.519	1.519	1.519
Central Luzon	1.390	1.390	1.392
Southern Tagalog	1.348	1.348	
Bicol Region	2.271	2.271	2.272
Western Visayas	1.548	1.548	1.548
Central Visayas	1.332	1.330	1.332
Eastern Visayas	2.095	2.094	2.095
Western Mindanao	1.819	1.742	1.751
Northern Mindanao	1.244	1.597	1.600
Southern Mindanao	1.985	1.741	
Central Mindanao	2.221	1.646	
National Capital Region	5.651	5.649	5.654
Cordillera Autonomous Region	1.630	1.629	1.630
Autonomous Region in Muslim Mindanao	0.806	1.090	1.152
Caraga	2.795	2.793	2.795
CALABARZON			1.494
MIMAROPA			1.735
Davao Region			1.747
SOCCSKSARGEN			1.646

Appendix 3. Weather stations per region.

REGION	Weather Stations
CAR	Aparri, Cagayan
ILOCOS	Laoag, Ilocos Norte; Vigan, Ilocos Sur
CVALLEY	Tuguegarao, Cagayan
CLUZON1	Cabanatuan, Nueva Ecija; Iba, Zambales
CLUZON2	Cabanatuan, Nueva Ecija; Iba, Zambales; Baler, Aurora
STAGALOG	Baler, Aurora; Infanta, Quezon; Tayabas, Quezon; Coron, Palawan; Puerto Princesa, Palawan; Romblon, Romblon
CALABARZON	Infanta, Quezon; Tayabas, Quezon
MIMAROPA	Coron, Palawan; Puerto Princesa, Palawan; Romblon, Romblon
BICOL	Daet, Camarines Norte; Legaspi City, Albay; Virac Synop, Catanduanes
WVISAYAS	Iloilo, Iloilo; Roxas City, Aklan
CVISAYAS	Dumaguete, Negros Oriental; Tagbilaran, Bohol
EVISAYAS	Catarman, Northern Samar; Catbalogan, Western Samar; Maasin, Southern Leyte; Tacloban, Leyte
WMINDANAO	Dipolog, Zamboanga del Norte (1990-2003); Zamboanga City, Zamboanga del Norte (2004-2009)
NMINDANAO1	Malaybalay City, Bukidnon
NMINDANAO2	Malaybalay City, Bukidnon
CMINDANAO	Cotabato City, Maguindanao
SMINDANAO	Davao City, Davao del Sur
DAVAO	Davao City, Davao del Sur
SOCCSKSARGEN	Cotabato City, Maguindanao
CARAGA	Butuan City, Agusan del Norte; Surigao, Surigao del Norte

Appendix 4. Additional Results

The researchers tried to further reduce the number of explanatory variables in the rice productivity equation to see whether this would result in the exact identification of the male migration equation. In this model, only the following were included: minimum temperature during January to June and July to December and their squared terms; maximum rainfall during January to June and its squared term; total rainfall during July to December and its squared term; and share of wet days in a year.

A joint test for the significance of weather variable and its squared term was used in deciding which pair of explanatory variables to maintain. Because of high correlation with minimum temperature during January to June, the minimum temperature during July to December and its squared term were maintained even though they are not jointly significant in both models of yield and gross revenue per hectare

Results show that all weather variables are jointly significant in both models although the F-Statistics in the gross revenue per hectare equation has significantly declined compared to the model described in the main text. The high R^2 show a very good fit of the models (Appendix 4.1).

The significant Kleibergen-Paap rk LM statistic at 99% confidence level shows that all migration models are not under-identified. Based on the Hansen J statistic, only the estimated equations of total OFWs and female OFWs per thousand population on rice yield are not over-identified at 95% confidence level (Appendix 4.2). When using the gross revenue per hectare as explanatory variable, only the equation of male OFWs per thousand population have remained over-identified at the 95% confidence level (Appendix 4.3). These are similar to the results obtained from the regression presented in the main text showing that the increase in the number of instruments used does not necessary lead to over-identification of model.

Appendix 4.1. Regression results of rice productivity on weather variables

Explanatory Variables	Dependent Variable	
	Yield	Gross Revenue Per Hectare
Minimum Temperature (Semester 1)	0.54762**	2.10248
	[0.01602]	[0.23021]
Minimum Temperature (Semester 1)^2	-0.01654**	-0.06402
	[0.02264]	[0.24852]
Minimum Temperature (Semester 2)	-0.57545	-2.18455
	[0.10874]	[0.32693]
Minimum Temperature (Semester 2)^2	0.01697	0.06324
	[0.11646]	[0.33805]
Maximum Rainfall (Semester 1)	-0.00046	-0.0309
	[0.87659]	[0.18923]
Maximum Rainfall (Semester 1)^2	0.00001	0.00014*
	[0.37321]	[0.09970]
Total Rainfall (Semester 2)	0.00055	0.00471
	[0.20541]	[0.20922]
Total Rainfall (Semester 2)^3	0.0000	0.0000
	[0.40091]	[0.53254]
Share of Wet days	-0.03648***	-0.32292***
	[0.00002]	[0.00356]
Constant	3.35002*	30.51589*
	[0.09401]	[0.08218]
Region FE	YES	YES
Year FE	YES	YES
F-Statistic (Joint Significance Test of All Weather Variables)	20.65***	3.29**
R-squared	0.885	0.885
Number of regcode	20	20
Observations	216	216
Note: Robust p-values in brackets, *** p<0.01, ** p<0.05, * p<0.1		

Appendix 4.2. Regression results of international and domestic migration on rice yield

Explanatory	Total OFWs/	Female OFWs/	Male OFWs/	Domestic Migrants/
Variables	1000 Population	1000 Population	1000 Population	1000 Population
Yield	-6.45592***	-7.42796**	-5.47370*	1.80294***
	[0.00492]	[0.01082]	[0.06459]	[0.00017]
Constant	21.21162***	22.93217***	19.41580***	20.11809***
	[0.00005]	[0.00056]	[0.00469]	[0.00000]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	37.16***	37.16***	37.16***	37.16***
Hansen J statistic	14.02*	7.49	22.71***	18.42**
R-squared	0.937	0.936	0.92	0.981
Observations	216	216	216	216
Note: Robust p-values in brackets, *** p<0.01, ** p<0.05, * p<0.1				

Appendix 4.3. Regression results of international and domestic migration on rice gross revenue per hectare

Explanatory Variables	Total OFWs/1000 Population	Female OFWs/1000 Population	Male OFWs/1000 Population	Domestic Migrants/1000 Population
Gross Revenue Per Hectare	-1.01952***	-1.25350***	-0.75885*	0.21595***
	[0.00237]	[0.00578]	[0.05772]	[0.00162]
Constant	25.24062***	29.04648***	20.89208***	20.25668***
	[0.00004]	[0.00066]	[0.00464]	[0.00000]
Region FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Kleibergen-Paap rk LM statistic	37.16***	37.16***	37.16***	37.16***
Hansen J statistic	11.91	5.36	19.93**	15.40*
R-squared	0.934	0.935	0.917	0.979
Observations	216	216	216	216
Note: Robust p-values in brackets, *** p<0.01, ** p<0.05, * p<0.1				

Strengthening local capacity in the economic analysis of environmental issues

Recent EEPSEA Research Reports

Exploring the Forestry Carbon Finance Potential for an Indigenous Cultural Community in the Philippines
Margaret M. Calderon, Nathaniel C. Bantayan, Florencia B. Pulhin, and Lourdes J. Cruz
2013-RR1

Response of Fishermen to Fishing Control Policies in Southern Songkhla Lake, Thailand: A Field Experiment
Kunlayanee Pornpinatepong, Pathomwat Chantarasap, Jumtip Seneerattanaprayul, and Wittawat Hemtanon, and Papitchaya Saelim
2013-RR2

Economic Analysis of Multi-pollutant Control in Coal-fired Electricity Plants in China
Wu Dan and Xie Xuxuan
2013-RR3

Impact of Piped Water on Household Welfare in Vietnam
Nguyen Viet Cuong, Vu Thieu, Pham Minh Thu, and Nguyen Xuan Truong
2013-RR4

Evaluating the Pilot Implementation of Payment for Forest Environmental Services in Lam Dong, Vietnam
Nguyen Thi Y Ly
2013-RR5

To Burn or not to Burn: Making the Burning of Chocolate Hills of Bohol, Philippines Carbon Neutral
Nathaniel C. Bantayan, Margaret M. Calderon, Florencia B. Pulhin, Canesio D. Predo, and Rose Ann C. Barruga
2013-RR6

An Economic Analysis of the Use of Water Hyacinth for Phytoremediation and Biogas Production in Dianchi Lake, China
Zanxin Wang and Jin Wan
2013-RR7

Economic Analysis of Rice Straw Management Alternatives and Understanding Farmers' Choices
Cheryll C. Launio, Constancio A. Asis, Jr., Rowena G. Manalili, and Evelyn F. Javier
2013-RR8

Impact of Eco-Labelling on Indonesia's Smallholder Coffee Farmers
Nuva, Yusif, Nia Kurniawati H., and Hanna
2013-RR9

Linking Climate Change, Rice Yield and Migration: The Philippine Experience
Flordeliza H. Bordey, Cheryll C. Launio, Eduardo Jimmy P. Quilang, Charis Mae A. Tolentiono and Nimfa B. Ogena
2013-RR10

Determinants of Flashflood Evacuation Choices and the Assessment of Preferences for Flashflood Warning Channels: The Case of Thailand
Kannika Thampanishvong
2013-RR11

Insurance Approach for Financing Extreme Climate Event Losses in China: A Status Analysis
Haitao Yin
2013-RR12

The Way to CO_2 Emission Reduction and the Co-benefits of Local Air Pollution Control in China's Transportation Sector: A Policy and Economic Analysis
Mao Xianqiang, Yang Shuqian, and Liu Qin
2013-RR13

Sida

IDRC CRDI