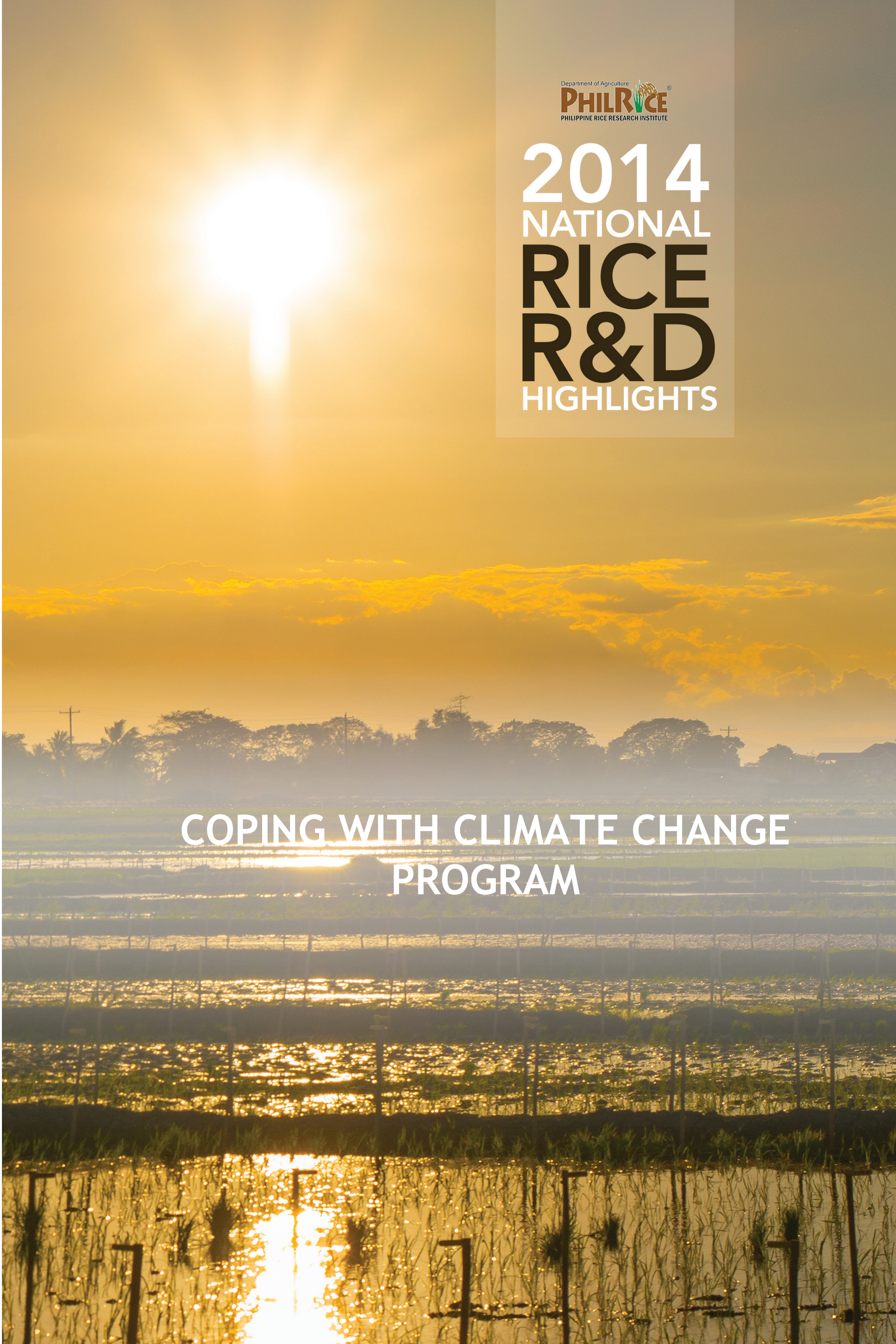

Department of Agriculture

PHILRICE

PHILIPPINE RICE RESEARCH INSTITUTE

2014 NATIONAL RICE R&D HIGHLIGHTS

COPING WITH CLIMATE CHANGE PROGRAM

TABLE OF CONTENTS

Coping with Climate Change Program

Program Leader: Ricardo F. Orge

Executive Summary

Rice is a climate-sensitive crop. The rise in ambient air temperature and the low solar radiation during prolonged rainy days, among other things, affect rice growth and development which ultimately results to low yields. Floods and droughts can also cause reduction in rice harvested area. Obviously, climate change is an additional and serious challenge to the country's goal for rice self-sufficiency. This Program was established in order to help attain this goal amidst the challenges brought about by climate change.

In 2014, six out of the eight studies under this Program were implemented. Two studies were discontinued due to some problems associated with human resource and budget. In spite of this however, the Program was able to come up with its major deliverables. One of them is the prototype of the controlled plant chamber which, when fully developed, would provide PhilRice researchers and those from partner agencies an opportunity to conduct basic researches that would require manipulation of weather parameters so as to help enhance our understanding on the effect of climate change on various aspects of rice production. In addition, three heat recovery attachments of the continuous rice hull carbonizer (oven, mushroom pasteurizer, and poultry heating system) were developed not only to reduce farmers' dependence on fossil energy but to provide additional income opportunities as a way of enhancing farmers' resilience to climate change. Moreover, the outputs of other studies provided initial information on the effect of weather parameter (such as temperature) on rice yield, and on how a farming community copes up with a seasonal flood that affects their living. Likewise, some enhancements of the PhilRice agro-meteorological stations were done through, among other things, the installations of 11 automatic weather stations.

I. Generation and management of local knowledge and information on climate change

Project Leader: JG Tallada

Inevitably, the general climatic patterns are bound to change as a result of unhampered accumulation of greenhouse gases in the atmosphere that were brought by incessant economic industrialization, and intensification of agriculture. The demand for an even greater amount of food will also exponentially increase brecause of rapid increase of population. Thus, this will increase the pressures to safeguard our food security.

Because of the miniscule total land area and population, the Philippines will not contribute significantly to the detriment of the climate. However, the country is in the forefront of bearing whatever the brunt of the ill effects of climate change owing to its geographical location. Recent experiences of weather extremes such as intensified typhoons and increased frequency of flooding, and the lenghtening episodes of El Niño are evidences of events that place the country in so much of a precarious position.

We may not be able to mitigate climate change but we can contribute to the understanding of its underpinning dynamics especially on how it will impact our currently vulnerable food security. At the cornerstone of this is ensuring the availability of reliable and quality weather data. The main goal of this project is to generate and manage local climate-related information and technologies in support to the climate change research.

Specifically the program aims to : 1) organize, systematize and manage the current weather stations of the institute; 2) collate, verify, summarize, store and deliver the daily weather and general climatic data they gather; 3) develop, test and deploy locally-assembled sensors and instrument systems integrated into automatic weather stations; and 4) to understand the impacts of climate change on crop production, pest and disease dynamics.

Enhancing PhilRice agro-meteorological monitoring capability and upgrading of facilities

MJPS Ancheta, JG Tallada, EJP Quilang, JL de Dios, AC Arocena, JM Maloom, MA Baliuag, CE Tayson, PL Sabes, JC Villarina, and GC Nunez

Inevitable changes in the environment was observed during the onset of industrial revolution and unprecedented scenarios like excessive increase or decrease of temperature, stronger typhoons and cyclones, impulsive pest and disease infestation are most likely experienced more often these times. Therefore a more in-depth data gathering procedure of climate and weather variable and parameters must be taken into consideration for research. Agro-meteorological data collection entails intensive gathering of weather related data with different methods and techniques of collection. Manual data collection perhaps is the ideal way of collecting weather data parameters (e.g. minimum and maximum temperature, relative humidity, and rainfall) but with its limitation on accuracy due to labor constraints and intervention, the trend is gradually shifting to the use of automatic weather stations. Advantages of automatic weather stations are the decline on human interference especially on the data collection which means greater precision and accuracy on data values. In addition, multiple data sets depending on the time interval can be transmitted through telemetries which disable the utilization of agro-meteorological data tally sheets. After the transmission, data processing procedure will be done and afterwards analysis and interpretation of processed data will be disseminated to stakeholders especially farmers and LGUs for policy making and execution of appropriate actions on abrupt variation of weather parameters.

Automatic Weather Stations (AWS) were established on various PhilRice branch stations to support rice research studies that need weather data. The main objective is to enhance PhilRice agro-meteorological monitoring capability through integration of agro-climate informatics in the collection, processing and dissemination of agro-meteorological data and information.

Highlights:

- In 2014, a total of eight AWS were installed in five PhilRice stations (Table 1). Six of these AWS were provided by other agencies like IRRI (4 units), PAGASA (1) and the FAO (1) through the AMICAF (Assessments of Climate Change Impacts and Mapping of Vulnerability to Food Insecurity under Climate Change to Strengthen Household Food Security with Livelihoods' Adaptation Approaches) Project implemented in the Philippines. Data collected from each AWS were sent to a primary server for the centralized data processing. Agro-meteorological focal persons from each PhilRice station were appointed to supervise the maintenance of these AWS.

Table 1. AWS installed at the PhilRice Stations in 2014.

Station	No. of AWS installed	Provided by
Agusan	3	AMICAF (1), IRRI (1), PAGASA (1)
CES	1	IRRI
Isabela	1	IRRI
Midsayap	2	IRRI (1), PhilRice (1)
Negros	1	PhilRice
TOTAL	8	

- Due to inconsistent data transmission observed in 2013, the data acquisition terminal of the Field Monitoring System (FMON) units at PhilRice was changed from Wi-Fi to GSM/GPRS transmission since GSM network provider is available and found more reliable. FMON is a kind of automatic weather station locally developed by the Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (DOST) which has the capability to send weather data from a remote location via Wi-Fi, Ethernet or

GSM/GPRS transmission. Data sets are transmitted to a server provided by DOST-ASTI and can be visualized on a webpage (fmon.asti.gov.ph). A total of five functional FMON units were installed at various PhilRice stations (two at CES and one each at Batac, Bicol and Isabela stations). Overall, there are a total of thirteen AWS installed in PhilRice Agromet stations (Figure 1). All of the AWS data are sent to PhilRice CES for validation and quality control and afterwards disseminated to requesting rice researchers and others stakeholders.

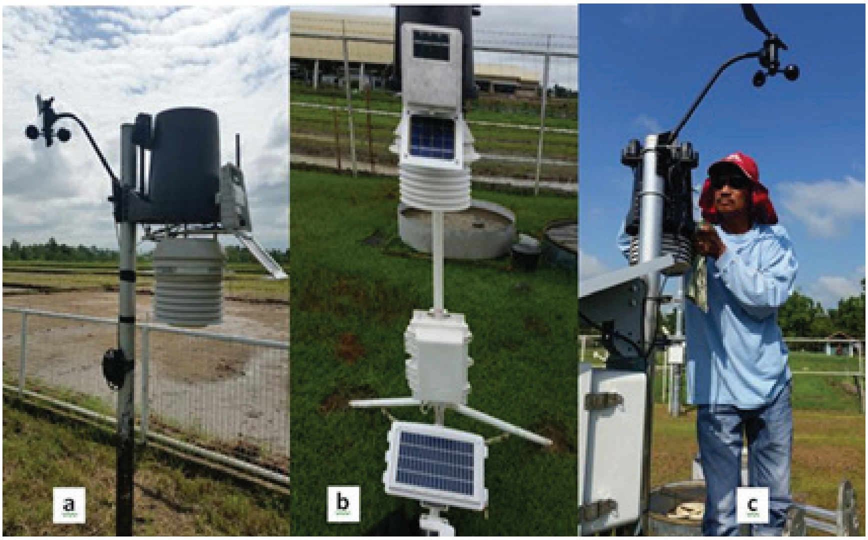

Figure 1. The AWS at PhilRice-Negros (a) and at CES (b) and an agromet focal person during repair and maintenance of FMON (c).

- The initial launch of weather@PhilRice webpage (Fig. 2) was undertaken. The webpage features weather data visualization through a webpage on near-real time interval for the benefit of PhilRice researchers for their daily planning of farm activity. Data transmitted from FMON units were utilized. Data visualization can be seen on an alternative website (fmon.asti.dost.gov.ph). On this website, data tables and trend lines of a weather variable on specific location are consolidated.

Figure 2. The weather@philrice webpage utilizing near-real time weather data from FMON.

Development of a controlled environment plant growth chamber
JG Tallada

Climate change is marked by higher environmental temperatures, heightened intensity of floods and drought, and significant changes in climatic patterns. It also leads to alterations in the patterns of biotic factors such as pest and disease incidence. These circumstances put greater pressure on food production, and there is a need to develop highly heat tolerant rice varieties and understand the new behavior of insects under higher temperature environment. To enable research on these aspects, it would be of great advantage to have a plant growth chamber that has the ability to control primarily the temperature, humidity and light conditions. But most of these scientific chambers are imported and costly. This study was conducted to design and develop a prototype plant growth chamber to service the research needs of the Institute, which will provide the basis for the design of a commercial level plant growth chamber.

Highlights:

- A prototype of a controlled environment plant growth chamber was constructed using locally available materials (Figure 3). It is equipped with a microcontroller-based control system which monitors the condition of the ambient air and other variables inside the chamber. Changes to the variables may be made according to the pre-programmed control pattern.

- The over-all body of the plant growth chamber was made from ¾inch thick marine plywood which enables easy fabrication. The main chamber had a 4ft. x 4ft. ($16ft.^2$) growing area. Four 400W metal halide lamps may be individually switched on according to programming instructions to simulate rising sun in the morning and the setting sun in the afternoon. The lights are placed in a separate chamber on the top to minimize interference with the main chamber temperature. A separate 8-inch ventilation fan maintains the light chamber temperature. Main chamber temperature control is achieved using two 1200W heaters to increase temperature and a ¾ hp air conditioner to decrease the temperature. The specified 38°C setting for high temperature tolerance experiments can be easily achieved. Humidity control is through a water mist system installed at the bottom of the main chamber.

- The chamber is equipped with a DHT22 sensor which can simultaneously monitor the air temperature and humidity. It had good measurement precision, and communication with the sensor can be easily handled by the microcontroller. Two axial ventilating fans circulate the air between the chamber and an auxiliary duct.

- An Arduino-based controller was programmed to read the environmental values from the DHT22 sensor and to control the lights, temperature and humidity through the solid state relays. The number of activated lights, set-point temperature and humidity can all be programmed on a 30-minute basis. This means that the conditions inside the chamber can be changed every half an hour.

- Testing and modifications were being made to reduce the entry of external air to and leakage of the internal air from the chamber. The four nozzle mister tested earlier was found not suitable because of the high water pressure requirement. A simpler single nozzle will be installed to the misting system. Finally, an air sealing pipe insulator will also be placed in the four access doors to minimize heat loss and air leakage.

Figure 3. The external and internal view of the prototype plant growth chamber.

Analyzing climate effect on rice using long term data at PhilRice-Central Experiment Station
AOV Capistrano

Historically, rice production in the country shows an increasing trend from 1970 up to the present. This span of time is also enough to assume that there has been a change in the climatic pattern following the globally accepted definition for climate change. An assessment of the rice production in the long-term against its corresponding climate is therefore being conducted to determine whether there really was climate change over this period and find out its effect on rice production. At PhilRice-CES in Nueva Ecija, a long-term fertility experiment (LTFE) has been in place since 1968. Yield responses and trends to fertilization treatments has been recorded from this long-term experiment which can also be used to assess the climatic contribution to such yield responses using the weather data as early as 1974 from the Agromet station of PAGASA at the Central Luzon State University, approximately 10km from PhilRice-CES. This analysis may help us understand how the changing climate affects rice production that we may continue to adapt our practices and develop technologies that increase or sustain rice production amidst climate change.

Highlights:

- Weather data from PAGASA Agromet station since 1974 was already collected and encoded in MS Excel.

- Weather data from the PhilRice Agromet Station since 1985 was already collected.

- Yield data from the LTFE since 1968 was also collected and summarized by variety used.

- Varieties to be analyzed according to the frequency of its use in the LTFE and the corresponding source of weather data for cross analysis are listed in Table 2.

Table 2. Varieties to be analyzed due to most frequent use in the LTFE.

Variety	Inclusive years	No. of years	Weather data source	Reason for choosing data source
IR29723-143-3-2	1984-1991	8	PAGASA CLSU	Data available since 1974
IR36	1976-1985	10	PAGASA CLSU	Data available since 1974
IR65620-192-3-3-3-2	2000-2007	8	PhilRice Agromet	Data available since 1985
IR72	1989-2007	19	PhilRice Agromet	Data available since 1985
IR8	1968-1991	14	PAGASA CLSU	Data available since 1974
PSB Rc52	1998-2013	16	PhilRice Agromet	Data available since 1985

- Daily average rainfall during the wet season (June to October) were derived per year and plotted against yield data by variety. Figure 4 shows an example of the WS average daily rainfall against the yield of a fully fertilized IR8. Based on the graph, a daily average rainfall of 7 to 12mm (bounded by 2 vertical bars) during the wet season results in yield averages of 3-5 t/ha. Daily rainfall averages outside the 7-12mm range results in lower yields as shown by the trendline projections.

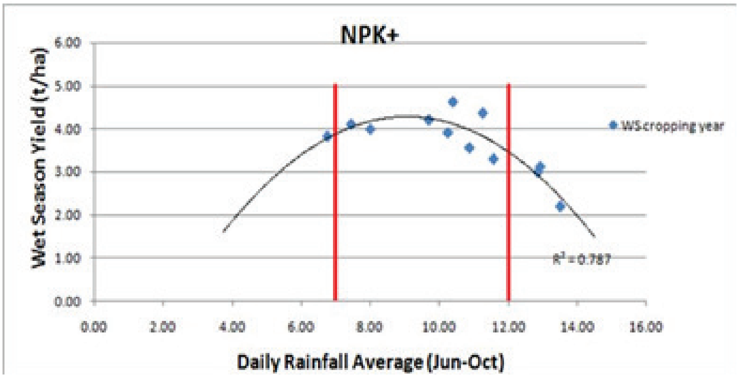

Figure 4. Yield response of IR8 at full fertilization against the daily rainfall average during the wet season.

However, only IR8 fitted this perfect parabolic curve. Other varieties produced inconclusive trends hence, this approach of analysis might not really be appropriate to use.

- The daily averages of the mean temperature during the wet season (June-October) were then derived per year due to the inappropriateness of the initial analytical approach. Figure 5 shows the yield of IR8 at full fertilization and the corresponding average daily mean temperatures during the period it was used in the LTFE. The graph shows that the yield of IR8 at full fertilization is inversely proportional to the average daily mean temperature. The trendlines of the two data sets indicate that for every 1°C increase in the average daily mean temperature during the entire wet season, a yield reduction of 1.91176 t/ha would be realized.

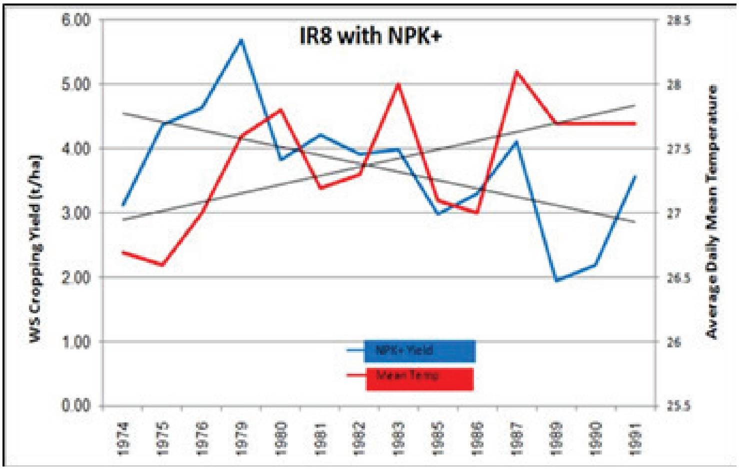

Figure 5. IR8 at full fertilization and corresponding average daily mean temperature from June to October.

- The daily mean temperature averages during the wet season (June-October) were again derived per year but this time using the PhilRice Agromet data. Figure 6 shows the yield of PSB Rc52 at full fertilization and the corresponding average daily mean temperatures during its use in the LTFE. The graph shows that the yield of PSB Rc52 at full fertilization is also inversely proportional to the average daily mean temperature. The trendlines suggest that for every 1oC increase in the average daily mean temperature during the entire wet season, there is a possible yield reduction of 2.1 t/ha.

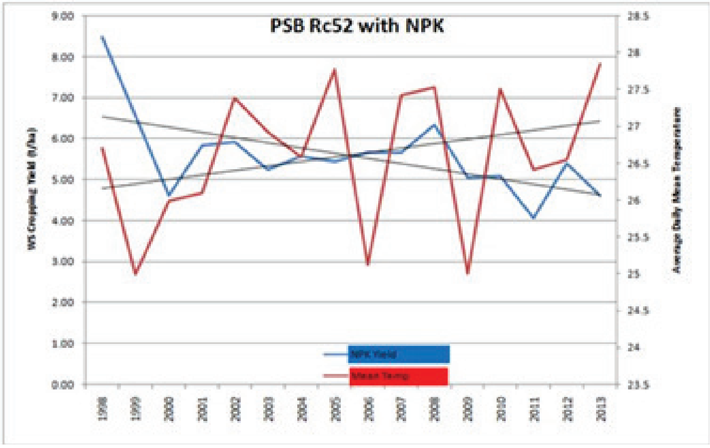

Figure 6. PSB Rc52 at full fertilization and corresponding average daily mean temperature from June to October.

II. Development of crop management strategies and decision support systems for climate change adaptation

Project Leader: AOV Capistrano

In agriculture, particularly for rice production, adaptation may come in different forms but may be specific for addressing a particular climate change impact. There are in actual four known climate change impacts that create uncertainty in agriculture, these are flooding, droughts, salinity intrusion, and extreme temperature. Coping with these impacts include breeding, cropping management technologies or adaptive strategies, decision support tools for various crop managements and policy recommendations for the institutionalization of adaptive strategies. With the onset of climate change impacts in the country, the importance of adaptation in rice production could not be emphasized more than ever. The onslaught of typhoons, subsequent droughts are just a preview of what the country could experience in the coming years. It is therefore imperative that a plan of action be put in place at the soonest possible time. Research and development initiatives must put all theories into practice to optimize technology potentials and equip the agriculture sector to minimize the effect of climate change impacts on food production.

This project aims to develop crop management strategies, new and innovative technologies, and decision support tools for rice production to cope with the impacts of climate change.

Improved rice-azolla farming systems for submergence-prone areas
GA Nemeño

This study was merged with other rice-azolla-related studies due to limited budget support

Utilization of different organic amendments in improving the growth and yield of rice in salt affected soils
DG Mayote

This study was discontinued due to limited budget support and lack of personnel to handle the study.

III. Enhancing the adaptive capacity of rice farmers through diversification of household sources of food and income

Project Leader: RF Orge

The Intergovernmental Panel on Climate Change (IPCC) states clearly that more people are projected to be harmed than benefited by climate change and those that will be harmed the most are those living in developing countries, particularly the very poor. Studies show that without adaptation, climate change is generally problematic for agricultural production and for agricultural economies and communities; but with adaptation, vulnerability can be reduced and there are numerous opportunities to be realized. Moreover, a lot of studies show that resilience to climate change can best be achieved through diversification of sources of income. Thus the growing of rice, being highly sensitive to extreme climate events needs to be complemented with other income-generating activities that would maximize the income that can be generated from a limited piece of farm land tilled by the farmers. This project is therefore being implemented to enhance the adaptive capacity of rice farmers through diversification of household sources of food and income.

Enhancing Resiliency of rice - producing households of flood-prone areas in CARAGA Region
ST Rivas, CA Mabayag and FL Varquez

Aside from being considered as one of the poorest region of the country, Caraga was also identified as one of the most sensitive regions to climatic irregularities, particularly flooding. As projected by PAGASA, flooding is expected to escalate in the next 20 years due to the increased performance of northeast monsoon particularly in provinces characterized under Type ll climatic regime. Agriculture remains an important industry in this region and the source of livelihood of the 39% of its workforce. Flooding will definitely affect the meager agricultural production, which might escalate food insecurity and income insufficiency as well as amplify socioeconomic problems already experienced by the region.

In this study, Agusan Del Sur was selected as the research site because it normally receives rainfalls ranging from 400-600mm in the months of December to January, according to its historical rainfall data from 2002 to 2011. Flooding frequently occurs in the municipalities located near Agusan marsh, a river basin that catches all the rain even those coming from parts of Davao and Bukidnon. In addition, the province has also the highest poverty incidence in 2010 according to National Statistical Coordination Board. Generally, this study aims to increase the adaptive capacity of flood-prone rice – producing households in the region. Specifically, it aims to: (a) determine and map actual poverty incidence in flood – prone areas in Caraga Region, (b) profile local crop production practices and introduce flood – smart crop production technologies adaptable to the area, (c) facilitate new income opportunities through skills enhancement trainings and/or livelihood programs, (d) determine and facilitate risk transfer management mechanisms appropriate to the rice farm household, and (e) package location – specific, flood – smart household resilience mechanisms and promote to policy – makers for adoption or incorporation to local policies.

Highlights:

- Conducted 2 immersions and meeting-consultation with farmer-participants for the implementation of the study in 2015 on December 11-12, 2014;

- Conducted socio-economic profiling for 25 participants. Among the findings of the survey were as follows:
  a. Demographics of the Household. The surveyed households are average in family size with relatively young children and matured parents. Average age of the head of the family is 46 while average age of the wife is 43. The average family size is 6 with 54% of the households having 1 to 2 children below 12 yrs old. Moreover, 50% of the households have 1 to 2 family members with age 18 and below and 17% of the households have relatives such as in-laws, grandchildren, and siblings of any of the head or the wife living in the household.

  b. Income and Expenditure. The household surveyed has a reported annual average income of Php 53,145.33. Major income source is agriculture, wages, and other enterprises such as firewood making. The households reported weekly food expenses of Php 1425.33 and consumes an average of 8.0 kg rice a week which comprises 25% of the food and beverages expenses. Aside from a regular purchase of fish and vegetables, the household also spent Php 1,942.58 for non-durable and frequently-purchased materials such as personal care, electricity bills fares and cell-phone load monthly. Php 7,593.88 was also spent by the household in 2013 for education, clothing, purchase of additional kitchen wares and others.

c. Education and health. Sixty three percent of the surveyed household had heads of the family which have finished elementary and secondary education. Fifty four percent of the households are sending their children to elementary school in the locality, while 42% are sending their qualified children to secondary schools 4km away from the locality. In addition, 8% of the household surveyed send their qualified household members to tertiary education to Agusan Del Sur State College of Agriculture and Technology.

d. Housing Conditions. Most of the households are living in a detached house, majority reported that they built the house and the home lots are theirs. Houses are predominantly made of galvanized iron sheets as roof, amakan (bamboo) and lumber as wall, and bamboo or lumber as floor. Eighty three percent reported to have a flush type toilet, and predominantly with make-shift bathroom. Seventy nine percent of the household surveyed has electricity while 100% reported that there is no potable water source, collected rain for drinking water or bought at a water rationing business. The main transportation for the surveyed household is motor vehicle (habal-habal), and 33% reported that they own a motorcycle for transportation. Main source of information is television for those who have electricity, but 100% has a mobile phone for SMS.

e. Welfare Indicators. The household felt generally safe from crime and violence and generally confident that the authorities can readily respond in times of violence and crisis. The households reported that in general, they consume fish 1 to 2 times per week and consume meat 2 to 3 times per month. However when asked what does their children below 12 years old had for breakfast on that day, 80% of the household with children below 12 years old had "milo" (chocolate drink) or milk and rice for breakfast. The rest reported that they prepared fish, vegetable, fish and vegetable, and rice for breakfast of their children. All the households reported to have own 1 mobile phone, and subscribe to unlimited SMS once to 2 times in a week.

f. Flood profile. All of the surveyed households has experienced flood last year in the months of January to February. The LGU did not provide any cropping calendar that is customized to the flooding situation in the locality. Flood levels during flood months can reach to 1.0m in the backyard and 0.5m in the rice fields. The flood usually stayed for 1 to 10 days.

g. Other observations. It has been observed that there is no community vegetable garden that can be a source of vegetables for the households. Most of the households also don't have vegetable gardens as a source of additional income or food for the household.

Figure 7. Meeting-consultation and socio economic survey in Antioquia, Kapatungan, Trento, Agusan Del Sur.

Maximizing the use of the continuous rice hull (CtRH) carbonizer in generating additional sources of income for enhanced climate change resiliency of rice-based farming communities
RF Orge and JEO Abon

A lot of studies show that resilience to climate change can best be achieved through diversification of sources of income. For the rice farming households to withstand or recover from any climate-related shocks, they need to have other income-generating activities and not only depend from rice production which is highly climate sensitive.

The production of rice hull into biochar using the PhilRice-developed CtRH carbonizer generates recoverable heat which could provide them such opportunities. Under the Palayamanan system of farming, biochar is popularly used as soil conditioner, animal bedding, and organic fertilizer ingredient, among other purposes. Thus while producing biochar which could be a regular activity in the farm, they can make use of this heat for additional income-generating activities. This study generally aims to maximize the use of the CtRH carbonizer by utilizing the otherwise-wasted heat in creating additional income opportunities for the farmers as a way of enhancing their resilience to climate change. Specifically, it aims to develop heat recovery attachments to the CtRH carbonizer and pilot test their use in the production of high value products.

Highlights:

- The oven attachment was further improved and a new prototype was fabricated (Figure 8). The design of the oven was made much simpler than the previous (2013) prototype to allow ease of local fabrication and ease of attachment to the CtRH carbonizer. To evaluate its performance, the 9-tray capacity oven (each tray measuring 78cm x 109cm x 5cm) was used to bake macaroons while temperature sensors were placed on trays representing the top, middle, and bottom portion of the oven. The macaroons were successfully baked after a period of 40 to 50 minutes. Shorter baking time was observed in trays close to the bottom (floor) of the oven, indicating that the closer the tray to the bottom, the higher is the temperature. Reults of the interview with those who have tasted the final product showed no difference in taste and texture with the macaroons baked in commercial LPG-fueled ovens. There were however some pieces which appeared to be darker in color than the others. Other products like young corn, chicken, squid and tilapia were successfully roasted using the oven.

- A sterilizer for mushroom fruiting bags was developed as an additional attachment to the CtRH carbonizer. This was done to further improve the current system of producing mushroom while maximizing the use of the carbonizer-generated heat. Series of design improvements and test runs had been done leading to the development of the 500-bag capacity sterilizer (one bag measuring 9.1cm dia x 18.3cm length) now being used at PhilRice-CES (Figure 9). It features an improved design of the steam generator which generates steam at an average rate of 6.59 l/h which is 111.2% higher than in the previous prototype. During actual use, the desired sterilization temperature of 60°C was reached within 1.92h, approximately 50% faster than the previous one (3.75h).

Figure 8. The improved prototype of the oven.

Figure 9. The 500-bag capacity mushroom pasteurizer.

- Because of an urgent need of a rice-and-poultry farmer to use the carbonizer as heat source in poultry, while producing carbonized rice hull as ingredient in the production of organic fertilizer, another heat recovery attachment was developed (Figure 10). This attachment was designed in such a way that it could be retrofitted in the existing heating system of the poultry house which is has liquified petroleum gas (LPG)-fueled burners and equipped with automatic controls. The resulting prototype was installed in a 40,000 bird-capacity poultry house to replace one LPG burner. Data gathered from its actual use in one poultry production cycle (35 days) showed that the CtRH carbonizer could provide the needed amount of heat comparable to that supplied by the LPG burners (Figure 11). However, there are some design refinements that have to be done to enhance its performance and durability when used under such kind of operating conditions.

Figure 10. The carbonizer used as heat source in poultry brooding.

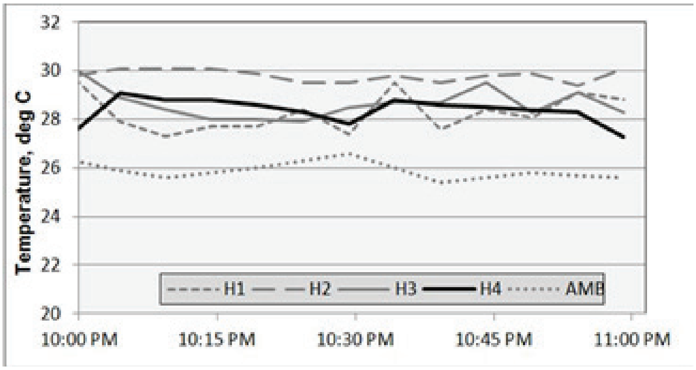

Figure 11. Temperature profile of air inside the poultry house as affected by heat source (LPG burner: H1 to H3; carbonizer: H4; outside air temperature: AMB)

Effect of Integrating two duck batches on arthropod diversity and methane emission from rice environment

JM Rivera, EM Valdez, FS Grospe, VT Dimaano , RG Corales

The integration of rice cultivation and duck farming rice is feasible and economically rewarding for the farm families because it enables them to obtain rice, additional income and subsidiary products, such as meat and eggs from the ducks in the same piece of land. Ducks also act as natural control agents against pests such as insects, weeds, rats, and golden apple snails. Normally, one batch of 100 to 150 ducklings is integrated into the rice paddies 10 days after the rice seedlings are transplanted. When rice plants reach heading stage, the grown ducks are then withdrawn. In this study, two batches of ducks were introduced in the rice paddies, the second one in the reproductive stage, so as to provide a safer full season protection of the rice crop from pests as well as provide additional income to farmers.

Highlights:

- Duck integration increased the rice yield of the recommended fertilizer rate by 0.88t/ha in the dry season and 0.42t/ha in the wet season. Duck integration further increased the rice yields to 1.52t/ha during the dry season and 1.45t/ha during the wet season when carbonized rice hull (CRH) was added to the recommended fertilizer rate (Table 3).

- Integrating two duck batches per season provided additional income of around Php 35,000.00/ha during the dry season and around Php 24,000.00 during the wet season.

- Treatments with ducks showed lower arthropod population based on sweep net and visual counts

- Measured CH_4 emission rates ranged from 3.7mg CH_4 m-2 h-1 to 12.1mg CH_4 m-2 h-1 in the dry season and from 2.5 to 7.6mg CH_4 m-2 h-1 in the wet season. High stocking density of ducks seemingly increase methane emission in the rice paddies (Figure 12 and 13).

Table 3. Rice yields as affected by duck integration. PhilRice CES. 2014.

Treatment	Dry Season (NSIC 202H)	Wet Season (PSB Rc160)	Mean
Control (No Fertilizer)	5.53 c	3.69 c	**4.61**
RFR (Recommended Fertilizer Rate)	6.79 ab	5.55 ab	**6.17**
RFRC (RFR with CRH)	6.37 bc	4.98 b	**5.68**
RFRD (RFR + Duck)	7.25 ab	5.97 ab	**6.61**
RFRCD (RFR with CRH + Duck)	7.89 a	6.43 a	**7.16**
Mean	6.76	5.32	6.04

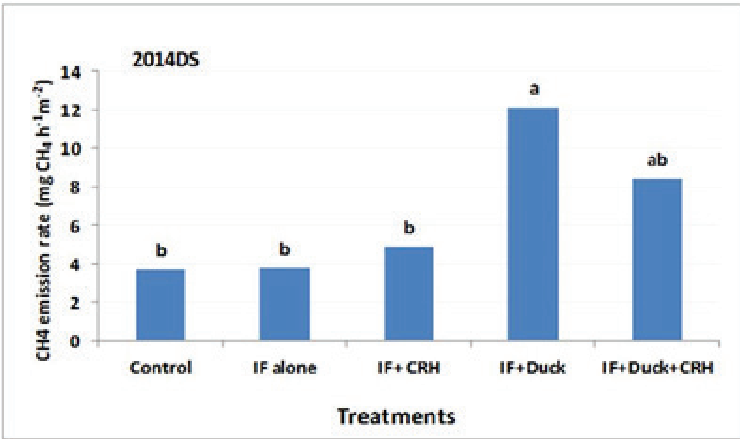

Figure 12. Seasonal methane emission of Mestizo19 hybrid rice cultivar as affected by different treatments. 2014DS, Philrice CES.

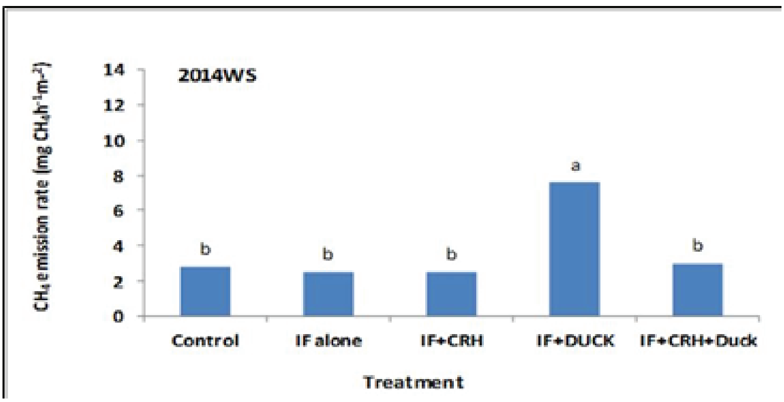

Figure 13. Seasonal methane emission of PSB Rc160 cultivar as affected by different treatments. 2014WS, Philrice CES.

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit

LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

List of Tables

List of Figures

PhilRice Central Experiment Station, Maligaya, Science City of Muñoz, 3119 Nueva Ecija • Tel: (44) 456-0277 • Direct line/Telefax: (44) 456-0112

Email: prri.mail@philrice.gov.ph • PhilRice Text Center: 0920-911-1398 • Websites: www.philrice.gov.ph; www.pinoyrkb.com
PhilRice Agusan, Basilisa, RTRomualdez, 8611 Agusan del Norte • Tel: (85) 343-0778•Tel/Fax: 343-0768 • Email: agusan.station@philrice.gov.ph
PhilRice Batac, MMSU Campus, Batac City, 2906 Ilocos Norte • Tel/Fax: (77) 670-1887; 670-1867 • Email: batac.station@philrice.gov.ph
PhilRice Bicol, Batang, Ligao City, 4504 Albay • Cell:0905-7352078, 0918-9467493 • bicol.station@philrice.gov.ph
PhilRice Isabela, Malasin, San Mateo, 3318 Isabela • Tel: (78) 664-2954, 2280 • Tel/Fax: 664-2953 • Email: isabela.station@philrice.gov.ph
PhilRice Los Baños, UPLB Campus, Los Baños, 4030 Laguna • Tel: (49) 536-8620•501-1917 • Email: losbanos@philrice.gov.ph
PhilRice Midsayap, Bual Norte, Midsayap, 9410 North Cotabato • Tel: (64) 229-8178 • Tel/Fax: 229-7242 • Email: midsayap.station@philrice.gov.ph
PhilRice Negros, Cansilayan, Murcia, 6129 Negros Occidental • Cell:0928-506-0515 • Email: negros.station@philrice.gov.ph
PhilRice Field Office, CMU Campus, Maramag,8714 Bukidnon • Tel/Fax: (88)222-5744
Liaison Office, 3rd Floor, ATI Bldg, Elliptical Road, Diliman, Quezon City • Tel/Fax:(02)920-5129, Cell:0920-9069052